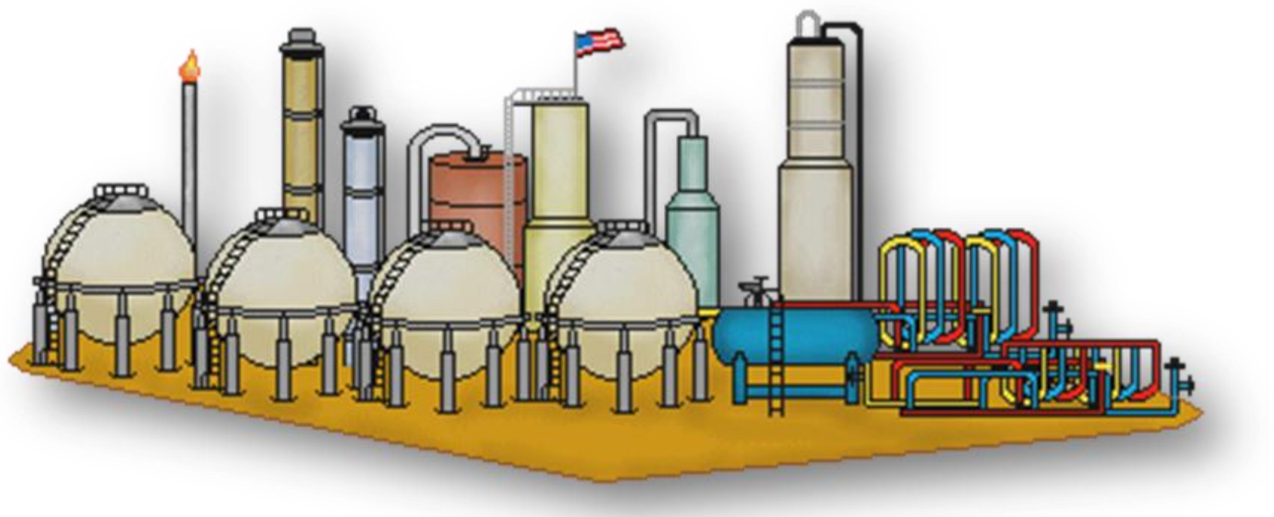
Technical Questions

[Oil-Gas – Chemical – Petrochemical Engineering]



Prepared By

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2015-2016

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مقدمة

بسم الله الرحمن الرحيم

{ وَمَنْ يَتَّقِ اللَّهَ يَجْعَلْ لَهُ مَخْرَجًا (٢) وَيَرْزُقْهُ مِنْ حَيْثُ لا يَحْتَسِبُ وَمَنْ يَتَوَكَّلْ عَلَى اللَّهِ فَهُوَ حَسْبُهُ إِنَّ اللَّهَ بَالِغُ أَمْرِهِ قَدْ جَعَلَ اللَّهُ لِكُلِّ شَيْءٍ قَدْرًا (٣) }

صدق الله العظيم

الحمد لله الذي لولاه ما جرى قلم، ولا تكلم لسان، والصلاة والسلام على سيدنا محمد (صلى الله عليه وسلم) كان أفصح الناس لسانا وأوضحهم بيانا. ثم أما بعد إنه من دواعي سروري أن أتيحت لي هذه الفرصة العظيمة لأكتب في هذا الموضوع الهام الذي يشغل بال كل طالب أو خريج أو مهتم بالعمل فى مجالات" الهندسة الكميائية و البتروكيماويات و معالجة الغاز و تكرير الزيت " هذا العمل نتاج سلسة محاضرات قمت باعدادها و تقديمها بنقابة المهندسين بدمياط. ان شاء الله سوف نستعرض و نستفيض فى معظم المواضيع و الأسئلة المتوقعة فى امتحانات الشركات المهتمة بالمجالات السابقة و كيفية الاعداد لهذا الامتحان من تنظيم للوقت و تحديد المواضيع و اعداد السيرة الذاتية بشكل جيد الى الجلوس امام المسئول و طريقة الرد و الاجابة على هذه الأسئلة .

وفقني الله وإياكم لما فيه صالحنا جميعاً

مهندس/ مسعد مسعد داود

مهندس بترول بشركة بترول خليج السويس "جابكو"

محاضر فى هندسة الغاز و البتروكيماويات بنقابة المهندسين

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إهداء

أهدى هذ العمل المتواضع الى.......

مـن علمني النجـاح والصبر ، إلى من افتقده في مواجهـة الصعـاب، ولم تمهله الدنيا لأرتوي من حنانه.. أبي، إلى من تتسابق الكلمات لتخرج معبرة عن مكنون ذاتها من علمتنى وعانت لأصل إلى ما أنا فيه..أمـى، إلى مـلاكى في الحيـاة إلى معنى الحـب و التفانى، إلى بسمـة الحيـاة و سـر الوجـود.. زوجتى الغاليـة

أقول لهم: أنتم وهبتموني الحياة والأمل والنشأة على شغف الاطلاع والمعرفة

الى أساتذتي

إلى زملائي وأصدقائى

إلى الشموع التي تحترق لتضئ للآخرين

إلى كل من علمني حرفا فأصبح سنا برقه يضيء الطريق أمامي

أهدي هذا العمل المتواضع راجياً من المولى عزوجل أن يجد القبول والنجاح

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Chapter 1

CV Preparation

اعداد السيرة الذاتية

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نصائح و تعليمات عند كتابة السيرة الذاتية

تعتبر السيرة الذاتية من الأدوات التى لها أهمية كبيرة في الحصول على فرصة عمل مناسبة. كثيراً ما يواجه حديثي التخرج مشكلة عدم علمهم بأسلوب كتاب السيرة الذاتية و لا أدري لماذا لا تقوم الجامعا ت بهذا الدور كما يحدث في الخارج. أحاول هنا تسجيل بعض النقاط الهامة من وجهة نظري و خبرتي الشخصية.

أولاً:

السيرة الذاتية هي وسيلتك لتعريف الناس بك فمن المهم أن تد ون فيها كل ما قد يؤثر على قرار اختيارك وأن تكون مستوفية للبيانات الأساسية. وبالتالي فأي سيرة ذاتية لابد و أن تحتوي على بيانات شخصية، التعليم، خبرة العمل، اللغات، معلومات إضافية . قد تضاف أقسام أخرى مثل التدريب، المهارات الشخصية، الأبحاث والمطبوعات . في الولايات المتحدة يفضلون كتابة قسم صغير في بداية السيرة الذاتية مكون من جملة توضح ما تهدف إليه مثل : الحصول على وظيفة مهندس في مجال الاتصالات .....ولكن يبدو أن هذا غير معتاد في المنطقة العربية و لذا أظن انه لا داعي لكتابة هذا القسم أصلا إلا إذا كنت تتقدم لشركة أجنبية فقد تُفكر في إضافته

ثانياً:

يفضل أن يكون عنوان السيرة الذاتية هو اسمك و تحته مباشرة عنوانك و التلفون و البريد الإلكتروني . في هذه الحالة يحتوي قسم البيانات الشخصية على جنسيتك و تاريخ ميلادك و النوع (ذكر أو أنثى) و الحالة الاجتماعية و ربما إن أردت وضع الديانة . إن لم تضع اسمك عنواناً للسيرة الذاتية فأضف اسمك وعنوانك وتلفونك و البريد الإلكتروني إلى البيانات الشخصية. كثيراً ما توضع صورة شخصية و قد يكون من الأفضل و ضعها عند الطلب.

Hassan K. Fareed
4 Khaleel Khalle St.,
Cairo, Egypt
Tel. 5644444444
hkhaleelq@cv.com

وهذا مثال لقسم البيانات الشخصية بالعربية ثم بالإنجليزية **Personal Information**

Date of Birth: October 26th, 1985
Marital Status: Married
Military Servcie: Exempted
Nationality: Egyptian

ثالثاً:

التعليم يجب أن يوضح آخر دراسة قمت بها و قد يوضح أكثر من دراسة ولكن إن كنت حاصلا على شهادة جامعية فيمكن أن تذكر الشهادة الثانوية كذلك ولكن لا تذكر شهادة الإعدادية أو الابتدائية . الأشياء الحديثة تذكر أولاً بمعنى أن أحدث شهادة تذكر أولا ثم الأقل حداثة و هكذا . لابد من توضيح اسم الجامعة و تاريخ الشهادة أو تاريخ بدء و نهاية الدراسة والتخصص تحديدا

University of Alex., Faculty of Engineering, Egypt. 1984-1989
BSc in Mechanical Engineering (Very Good Honors)

رابعاً:

الخبرة العملية تكون مسلسلة أيضاً بداية بأحدث وظيفة ثم الأسبق و هكذا .يجب أن توضح لكل وظيفة اسم الشركة أو المؤسسة، تاريخ بداية و نهاية التوظيف، المسمى الوظيفي، الأ عمال و المسئوليات والإنجازات ...ملحوظة يجب تحديد الفترة الزمنية أثناء سرد الخبرات العملية .

Work Experience
SAMAA Co., Cairo, Egypt Jan 1995- Present
Production Engineer – Acid Plant
Supervised the operations of a plant (productivity 200 tons/day)
Modified the main equipment and increased productivity by 15%
Trained 20 production technicians
Saved 200000 LE by improving the maintenance system

خامساً:

المهارات تحتوي على اللغات و الكومبيوتر و أي مهارات أخرى . اكتب اللغات التي تعرفها و درجة معرفتك بها . وكذلك اكتب أي برامج تجيد استخدامها من البرامج العادية إلى البرامج المتخصصة مثل:

Languages
Arabic Mother Tongue
English Good

Computer Skills
Highly skilled in Windows, MS Office
Basic Awareness of AutoCAD

سادساً:

التدريب يحتوي على أي برامج تدريبية قد تكون ذات علاقة بالعمل الذي تبحث عنه مثل الدورات الإدارية و الفنية و دورات الحاسوب و اللغات

سابعا:

قسم المعلومات الإضافية يحتوي على أي معلومات لم تستطع كتابتها في أي قسم آخر.
حاصل على الحزام الأسود في الكاراتيه ...الطالب المثالي في كلية كذا .....جائزة التفوق الثقافي من كلية كذا...عضو في جمعية المهندسين العرب

<u>أخيراً : نصائح عامة</u>

- ☒ لا تكذب. لا تبدأ عملك بالكذب! وكذلك فإن كذبك قد يُكتشف أثناء المقابلة الشخصية وهو ما يجعل الممتحن يفقد الثقة فيك تماما. وقد يكتشف الكذب بعد تعيينك وهو ما يعرضك لمشاكل عديدة . لا مجال للأخطاء اللغوية اكتب السيرة الذاتية باللغة المطلوبة. كثيراً ما تطلب بالإنجليزية ولكن قد يحدث أن تطلب أيضاً بالعربية.
- ☒ لا تستخدم كلمة "أنا" أو "نحن" في السيرة الذاتية
- ☒ لا تهمل كتابة أشياء قد تبدو لك بسيطة ولكنها من وجهة نظر صاحب العمل قد تعني الكثير. فمثلاً إن كنت قد مثلت جامعتك كعضو في فريق في لعبة جماعية أو حصلت على جوائز في لعبة فردية فذاك يشير إلى أن لديك روح الفريق في الحالة الأولى و الإصرار والعزيمة في الحالة الثانية.
- ☒ لا تستخدم خطا كبيرا جداً فعادة ما يكون مقاس ١٢ مناسباً وكذلك لا تستخدم خطوط جمالية أو مائلة وحاول استخدام خطوط الكتابة العادية لا تستخدم رسومات أو تضع أشياء جمالية.
- ☒ لا تكتب قصصا واستخدم جملا قصيرة. لا وقت لدى قارئ السيرة الذاتية لقراءة جملا طويلة

- ☒ حاول أن تكون السيرة الذاتية مكونة من صفحة أو اثنين إن كنت حديث التخرج، ومن صفحتين إلى أربعة إن كانت لك خبرات طويلة ومختلفة
- ☒ حاول اختيار اسم مناسب لبريدك الإلكتروني الذي تكتبه على السيرة الذاتية والذي تُراسل به جهات التوظيف.
- ☒ إن كان مشروع التخرج له علاقة بالوظيفة المطلوبة فيفضل ذكره
- ☒ كلما زادت سنين الخبرة كلما قلت أهمية ذكر أمور تفصيلية قديمة مثل مشروع تخرجك من عشرين عاماً
- ☒ لاحظ أن النماذج الجاهزة للسيرة الذاتية في ميكروسوفت وورد **MSWorsd** لا تحتوي على قسم البيانات الشخصية وتحتوي على قسم خاص للهدف. بمعنى آخر فإنها مُصمَّمة على الأسلوب الأمريكي
- ☒ استخدم تنسيق موحد لكتابة جميع أقسام السيرة الذاتية فلا تكتب عنوان القسم الأول بخط كبير ثم عنوان قسم آخر بخط صغير ولا تكتب اسم وظيفة بخط سميك واسم وظيفة أخرى بخط عادي ولا تكتب التاريخ مرة على اليمين ومرة على اليسار
- ☒ كُن حذراً في استخدام الأحرف الأولى أي الاختصارات فربما لا تكون مفهومة للقارئ فمثلا **PM** ربما تكون غير مفهومة وبالتالي يفضل كتابة الاسم بالتفصيل وهو **Preventive Maintenance**. بعض الاختصارات لا يحتاج شرح لأنه معلوم للجميع مثل **BSc, MSc, PhD**.
- ☒ لا تبالغ في تعظيم قدراتك
- ☒ خذ في اعتبارك أن لكل بلد بعض الأعراف المختلفة في كتابة السيرة الذاتية فإذا علمت أن شيئاً ما عادةً ما يكتب أو عادة لا يكتب في السيرة الذاتية في البلد الذي تود أن تعمل به فحاول أن تتبع هذا العُرف
- ☒ حاول تَحديث السيرة الذاتية من آنٍ لآخر بإضافة الخبرات والإنجازات الجديدة

بعض المواقع المفيدة لعمل سى فى جيد

- ☒ www.getfreecv.com
- ☒ www.kickresume.com
- ☒ www.enthuse.me
- ☒ www.onlinecvgenerator.com

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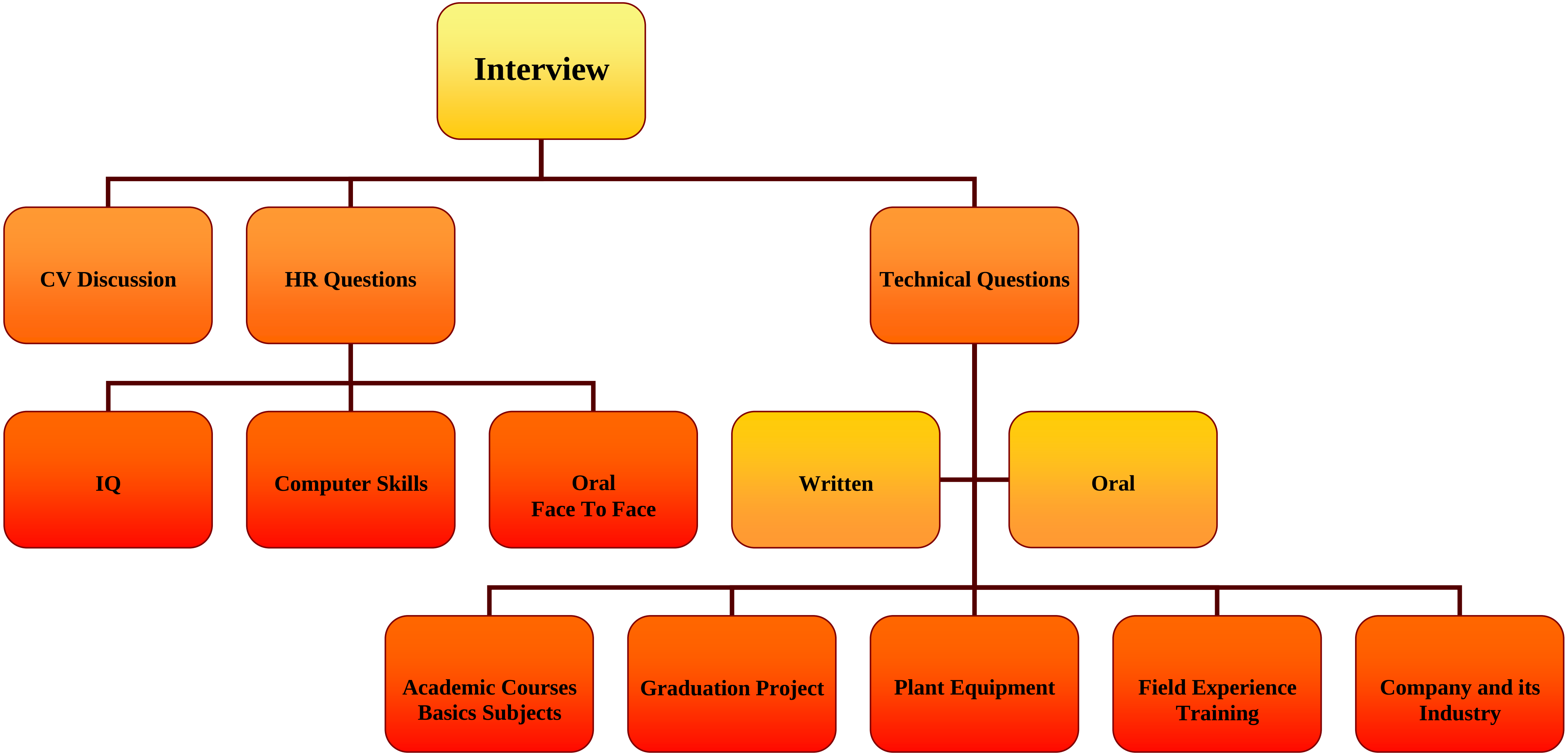
Chapter 2
Interview Stages
مراحل المقابلة الشخصية



Interview
CV Discussion
HR Questions
Technical Questions
IQ
Computer Skills
Oral
Face To Face
Written
Oral
Academic Courses
Basics Subjects
Graduation Project
Plant Equipment
Field Experience
Training
Company and its
Industry

Chapter 3

Main Academic Subjects

المواد الدراسية الأساسية

Main Points in Heat Transfer

Important Definitions

Thermal Energy Can Be Divided to Tow General categories:

- **Heat**
- **Stored Internal Energy Of Substance**

1- Heat

Heat is not state of the material , it's the transfer of Energy Caused By Temperature Difference .
When heat is passed from one body to another the internal energy of the bodies Change.
Heat is Energy in Transit. Recall the First law from Thermodynamics. $\Delta U = Q - W$

2- Stored Internal Energy

Is the amount of Energy Processed By Substance it Can Be Considered to be the total molecular Energy of Body

3- Heat Transfer

Heat transfer is the transfer of Heat effected by a temperature difference

4- Latent Heat Of Vaporization

When matter changes from liquid to vapor or vice versa, it absorbs or releases a relatively large amount of heat without a change in temperature.(970 Btu)

5- British Thermal Unit " BTU"

Is the quantity of heat needed to raise the temperature of 1 lb. of water one degree Fahrenheit.

6- Specific heat :-

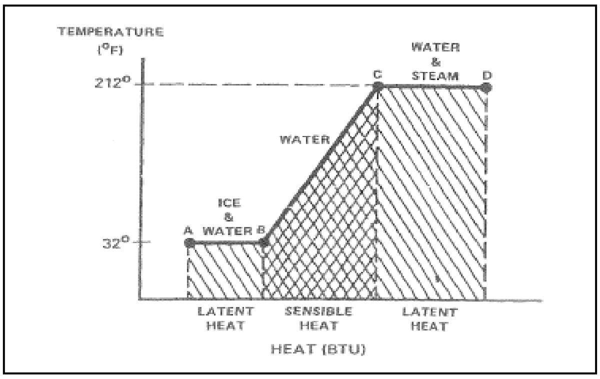
Amount of heat needed to increase the temperature of a pound of a particular substance 1f (the unit specific heat is BTU per pound per degree Fahrenheit (BTU/lb/f) .

7- Latent heat :-

Heat transfer can occur with no temperature change taking place this heat transfer is referred to as latent heat transfer .latent heat transfer results in phase change , that is a substance changes from solid to liquid , liquid to solid , liquid to gas or gas to liquid .

8- Sensible heat

When an object is heated, its temperature rises as heat is added. The increase in heat is called sensible heat. Similarly, when heat is removed from an object and its temperature falls, the heat removed is also called sensible heat. Heat that causes a change in temperature in an object is called sensible heat .



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Mention the Heat Transfer Mechanisms (Modes)

- ☒ ***Conduction*** involves the transfer of heat by the interactions of atoms or molecules of a material through which the heat is being transferred.ρ
- ☒ ***Convection*** involves the transfer of heat by the mixing and motion of macroscopic portions of a fluid.
- ☒ ***Radiation or radiant heat transfer,*** involves the transfer of heat by electromagnetic radiation that arises due to the temperature of a body.

1- Conduction

Conduction Is The Heat Transfer Between Two Substances By Direct Transferring Of Molecular Kinetic Energy . Conduction Occurs When A hot Substance Comes Into Contact With A cold Substance : Heat Is transferred From Hotter Substance Has A higher Temperature Than The Colder Substance , The Substance With A higher Temperature Has Molecules With Higher Average Kinetic Energy Than The Substance With The Lower Temperature .

heat transfer rate by conduction speed related to four factors :-

- Thermal conductivity of the substance
- The surface area over which the heat is applied
- The thickness of the material subject to the heat transfer
- The temperature difference across the materials

Fourier's Law of Conduction $Q = k\ A\ \Delta T/L$

$\dot{Q}$ = rate of heat transfer (Btu/hr)
A = cross-sectional area of heat transfer (ft2)
Δx = thickness of slab (ft)
Δr = thickness of cylindrical wall (ft)
ΔT = temperature difference (°F)
k = thermal conductivity of slab (Btu/ft-hr-°F)

2- Convection

- Convection heat transfer involves fluids, either liquids or gases in motion
- convection heat transfer occurs in two parts :
  - Heat transfer into or out of a fluid by the process of conduction
  - The movement of the fluid transports the heated fluid, as well as its thermal energy, to another location
- Convection either natural or forced (using fans, pumps or other devices).
- Also the increased turbulent of the forced flow will increase convective heat transfer rate as a result of increased heat transfer coefficient.

Newton's Law Of Cooling $\dot{Q} = h\ A\ \Delta T$

$\dot{Q}$ = rate of heat transfer (Btu/hr)
h = convective heat transfer coefficient (Btu/hr-ft2-°F)
A = surface area for heat transfer (ft2)
ΔT = temperature difference (°F)

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3- Radiation

Is the energy emitted by matter in the form of electromagnetic waves (or photons) as a result of the changes in the electronic configurations of the atoms or molecules.

- Unlike conduction and convection, the transfer of energy by radiation does not require the presence of an intervening medium.
- All bodies at a temperature above absolute zero emit thermal radiation.

Black Body Radiation

A body that emits the maximum amount of heat for its absolute temperature is called a black body. Radiant heat transfer rate from a black body to its surroundings can be expressed by the following equation.

$$\dot{Q} = ðAT^4$$

˙Q = heat transfer rate (Btu/hr)
ð= Stefan-Boltzman constant (0.174 Btu/hr-ft2-°R4)
A = surface area (ft2)
T = temperature (°R)

Two black bodies that radiate toward each other have a net heat flux between them. The net flow rate of heat between them is given by an adaptation of Equation

$$Q = ð\, A(T_1^4 - T_2^4)$$

A = surface area of the first body (ft2)
T1 = temperature of the first body (°R)
T2 = temperature of the second body (°R)

Emissivity

Real objects do not radiate as much heat as a perfect black body. They radiate less heat than a black body and are called gray bodies. To take into account the fact that real objects are gray bodies, so the previous equation will be modified to.

$$\dot{Q} = \varepsilon\, ðAT^4$$

where:
Ɛ = emissivity of the gray body (dimensionless)

Emissivity is simply a factor by which we multiply the black body heat transfer to take into account that the black body is the ideal case. Emissivity is a dimensionless number and has a maximum value of 1.0.

Example

The heat transfer that takes place in boiler furnace is a good example of the three modes of heat transfer :

- ☒ Conduction : heat transfer through the tube walls to the water in the tubes .
- ☒ Convection : heat transfer from the hot combustion gases to the water in the tubes
- ☒ Radiation : burning fuels transferring heat to the combustion gases and the tube walls

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Some Notes

- Heat ALWAYS flows from hot to cold when objects are in contact or connected by a good heat conductor. The rate of heat transfer will increase as the difference in temp between the two objects increases
- Cold objects have less heat than hot objects of the same mass
- The mass of the object remains the same regardless of the heat content
- Changing the pressure on a liquid or a vapor changes the boiling point.
  Each lb. of pressure above atmospheric pressure, raises the boiling point about three degrees Fahrenheit.
- When a vapor is compressed, its temperature and pressure will increase even though heat has not been added
- ***Convection*** : Occurs only in liquids, gases or vapors
  The transfer of heat by the circulation of a liquid or a vapor (like cooling system)
  Heat flows from a hot surface to a surface containing less heat.
  Heat rises. (Like on a stove)
- ***Radiation*** : The process that moves heat from a heat source to an object by means of heat rays without the medium becoming hot.
  Works on the principle that heat moves from a hot surface to a surface with less heat.
  Does not require air movement or anything in between the source and component. (Like rays of the sun)
- ***Conduction*** : Heat is transferred through a solid and gets the solid hot. (molecules get hot than they in turn give motion to nearby molecules and they get hot too)
  Different solids conduct different amounts of heat in a specific time. (copper vs. glass)

Factors affecting heat transfer between fluids

- ***Types of fluid or substance*** **,** e.g. liquids are better than gases .
- ***Types of materials***
  some materials transfer heat is better than others metals are better conductors than non metals
- ***thickness of materials*** **,** the thinner material , the faster heat will transfer **.**
- ***Surface area*** **,** the greater the contact surface area , the more heat transfer takes place
- ***Gravity of fluids*** **,** the tighter a fluid , the fester heat will transfer
- ***Turbulence of fluids*** **,** the greater the turbulence the better heat will transfer **.**
- ***Temperature difference*** **,** the greater difference in a fluid temperature, the faster heat will transfer, the greater driving force causing heat transfer
- ***Thermal conductivity,*** every substance has a definite thermal conductivity which affects the amount of heat transferred. Metals are good conductors while wood and carbon are very poor conductors .
- ***Velocity of the fluids in the tube,*** the velocity effect on fouling, with higher velocities reducing the possibility of scale or dirt deposits on tube .as the velocity increase the heat transfer rate Increase .

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- ***Direction of flow of the liquids exchanging,*** When using identical equipment with equal rates of flow, the one with counter current flow and the other with parallel (co-current) flow , the final temperature will be higher with counter current .
- ***Amount of liquids ,***The effect of higher flow rates and thinner film result in higher heat transfer rates as shown in the figure below **.**

The effect of fouling or deposits on the walls o f heat exchanging decreasing heat transfer rate

Types of fouling

- ***Scaling***
- ***Particulate fouling***
- ***Chemical reaction fouling***
- ***Corrosion fouling***
- ***Biofouling***
- ***Freezing fouling***
- ***Air or gas blanketing***

Function Of Heat Transfer Equipment

A- ***Cooler :*** Reduce The temperature of a liquid or gas using water to remove heat

B- ***Condenser*** : Remove Heat from a gas, changing it to a liquid

C- ***Vaporizer :*** Add heat to liquid , changing it to a gas

D- Evaporators : Employed for concentration of the solution by evaporation of water

E- ***Reboiler :*** Provide heat as latent heat to liquid in the bottom of a distillation tower . the heat may be supplied by either stream or a hot process stream

F- Chiller : Cool a liquid or gas using a refrigerant instead of water

G- ***Exchanger*** : perform two functions. They can heat a cold process stream by using a hot process fluid , or they can cool a hot process stream by using a cold process fluid

What's the Differnce between Heat Transfer and Mass Trnsfer …Mention examples for each

Heat transfer is the motion of thermal energy in transit due to a temperature difference. That is, whenever there is a temperature difference in a medium or between mediums, heat transfer must occur .There are three main modes of heat transfer: conduction, convection, and radiation .
Similarly, mass transfer is mass in transit due to a concentration difference. Therefore, if there is a difference in the concentration of some species in a mixture, mass transfer must occur. Just as the driving potential for heat transfer is a temperature gradient, a species concentration gradient is the driving potential for mass transport of that species. The analogy of heat transfer to mass transfer is correlated to the individual modes by which they are influenced. Mass transfer by due to fluid flow relates to convective heat transfer, and mass transfer by diffusion is analogous to conduction HT .

Mass transfer Example : Distillation Column …..Heat Transfer Example : Heaters etc

Main Points in Thermodynamics

Important Definitions

1- Intensive properties:
Are those independent of the size of system such as(Temp., Pressure and density).

2- Extensive properties:
Are those dependent on the size of system such as (Mass, Volume and Energy). Stored Internal Energy

3- Specific properties:
Extensive properties per unit mass $(v = \frac{V}{m}, h = \frac{H}{m}, e = \frac{E}{m}, \ldots.)$

Mass & Energy conservation:

$$m_{in} - m_{out} = \Delta m_{system}$$

Einestien Rule: E =MC^2 …. where C is the speed of light =3 ×10^8 m/s

4- Mass flow rate:
amount of mass flowing across-section per unit time ($\dot{m}$).

5- State:
a condition of a system at which all the properties have fixed values.

6- Equilibrium:
implies a state of balance.

7- Thermal Equilibrium:
when temperature is the same throughout the entire system.

8- Mechanical Equilibrium:
there is no change in pressure throughout the entire system.

9- Phase Equilibrium:
the mass of each phase reached an equilibrium value and stayed there.

10- Chemical Equilibrium:
when chemical composition does not change with time.

11- The state postulate:
The state of a simple compressible system is completely specified by two independent intensive properties.

12- **Process:**
any change that a system undergoes from one equilibrium state to another.

13- Path:
A series of states through which a system passes through a process.

14- **Quasi-equilibrium:**
when a process proceed in such a manner that the system remains close to an equilibrium state at all times.

15- Isothermal:
a process during which the temperature is constant.

16- Isobaric:
a process during which the pressure is constant.

17- Isochoric:
a process during which the volume is constant.

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Thermodynamics can be approached in either of two, usually distinct, ways:

1- Statistical thermodynamics or microscopic or molecular approach
2- Classical thermodynamics or macroscopic approach

Newotn's Laws

1st law: If the net forces are balanced (i.e. if the vector sum is zero), the object will not accelerate

2nd law: The force is proportional to the rate of change of momentum

3rd law: If one object exerts a force on another, then the second object exerts an equal but opposite force on the first.

Energy Calssification

1-Stored energy which is contained within the system boundaries. [potential energy ,kinetic energy, internal energy ....etc.]

2- Energy in transition which crosses the system boundaries. [heat , work , electrical energy ....etc.]

Transferred Energy

• Heat (Q) Driving potential : temperature difference
• Work - mechanical (Wm) Driving potential : unbalance in mechanical forces
• Work - electrical (We) Driving potential : voltage difference

Intrinsic or internal energy

• **Molecular:**
- Kinetic (Uk) Associated with absolute temperature
- Potential (Up) Associated with intermolecular or interatomic forces

• **Atomic:**
- Chemical (Uch) Associated with changes in molecular structure

• **Subatomic:**
- Nuclear (UNu) Associated with changes in atomic structure

The internal energy $U = Uk + Up + Uch + UNu$
The energy of the system $E = PE + KE + U$
Total Energy $E = 0.5mv^2 + mgz+U$

The zeroth Law of thermodynamics:

If two bodies are in thermal equilibrium with a third body they are also in thermal equilibrium with each other.

Compressed Liquid (sub-cooled): Liquid under conditions that's not about to vaporize.

Saturated Liquid: Liquid which is about to vaporize.

Saturated vapour: Vapour which is about to condense.

Superheated vapour: Vapour which is not about to condense.

Saturation Temperature: the temperature at which a pure substance changes phase at a given pressure.

Latent Heat: the amount of heat released or absorbed during a phase change.

Compressibility factor: a measure of deviation from ideal gas behavior.

$$Z=1 \text{ for ideal gas } Z < \text{ or } > 1 \text{ for real gas}$$

Z factor is approximately the same for all gases at the same reduced temperature and pressure(The principle of corresponding states).

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Van Der Waals EOS:

$$\left(P + \frac{a}{v^2}\right) \times (V - b) = RT$$

Where, b → the volume occupied by the gas molecules.

$\frac{a}{v^2}$ → intermolecular attraction forces.

Specific Heat: The energy required to raise the temperature of a unit mass of a substance by one degree. (kj /kg.°C)

$$C_v \rightarrow specific\ heat\ at\ constant\ volume$$

$$C_p \rightarrow specific\ heat\ at\ constant\ pressure$$

$$C_p = C_v + R$$

Heat: is the form of energy that transfers between two systems due to temperature difference (Q KJ).

Adiabatic Process: a process during which there is no heat transfer (Q=0).

Work: is the energy transfer associated with a force acting through a distance (KJ).

Path function: a property which magnitude depends on the path followed during a process as well as end states such as heat & work.

Point function: a property which depends on the state only and not on how the system reached it like volume.

Mechanical work: $W = F \times S$

F→ $Force$,S→ $Distance\ in\ direction\ of\ force$

Electrical work: $W = V \times I$

V : Potential Difference

I : Current

Shaft work: W=$2\pi nT$

F=$\frac{T}{r}$, S=$2\pi rn$

Spring work: W=$^1/_2\, K({X_2}^2 - {X_1}^2)$

1st law of thermodynamics:

Energy cannot be destroyed nor created only change from on form to another.

Steady flow process: a one the fluid flows through a control volume steadily (No change with time).

Turbine: Work is positive as it's done by the fluid.

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Compressors, Pumps &Fans: Work is negative as it's from another source and is supplied to the fluid.

Throttling valves: small devices cause a pressure drop which is accompanied with a temperature drop

Joule-Thomson co-efficient: determine the magnitude of that temperature drop.

Isenthalpic action h1=h2.

2nd law of thermodynamics:

- ☒ Determine the direction of heat transfer.
- ☒ Asserts that energy has quality as well as quantity.
- ☒ Determines the theoretical limits for the performance of commonly used engineering systems.
- ☒ Predict the degree of completion of chemical reaction.

Kelvin-Planck statement:

''It's impossible for any device that operates on a cycle to receive heat from a single reservoir and produce a net amount of work''.

Or, ''No heat engine can have a 100 % thermal efficiency''

Heat Engine:

A device that converts heat to work.

1. Receives heat from a source.
2. Converts part of it to work.
3. Delivers the waste heat to a sink.
4. Operate on a cycle.

Such as , Gas Turbine and Car Engine.

Steam Power Plant:

Works on a thermodynamic cycle like (External combustion Engine).

Thermal Efficiency:

$$\eta_{th} = \frac{W_{net,out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}} = 1 - \frac{Q_L}{Q_H}$$

Clausius statement:

''It's impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower temperature body to a higher temperature one''.

Energy efficiency rating EER:

The amount of heat removed from the cooled area in BTU for 1 wh of electricity consumed.

Refrigerators:

Devices that transfer heat from low temperature medium to a high temperature one.

$$COP_R = \frac{Q_L}{W_{net,in}} = \frac{Q_L}{Q_H - Q_L}$$

COP_R may be > 1 as; amount of heat removed can be greater than work input.

Heat Pump: **the same p urpose of refrigerators but the reverse objective.**

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Main Points in Fluid Mechanics

There are two types of fluid flow in pipelines:

- Single-phase flow : gas or liquid
- Multiphase flow : a mixture of gas and liquid

1. Single Phase Flow

There are two types of single-phase flow in pipelines : one being designated as streamline flow (sometimes called laminar or viscous flow), and the other as turbulent flow.

1.1 Streamline or Laminar Flow

Streamline or laminar flow is characterised by the gliding of concentric cylindrical layers past one another in orderly fashion. Velocity of the fluid is at its maximum at the pipe axis and decreases sharply to theoretical zero at the pipe wall.

1.2 Turbulent Flow

In turbulent flow, there is an irregular random motion of fluid particles in directions transverse to the direction of main flow. The velocity distribution in turbulent flow is more uniform across the pipe diameter than in streamline flow.

1.3 Stages of Flow

At low flow velocity, the streams of liquid flow in straight line. This is streamline or laminar flow. As the flow rate is gradually increased, these streams will continue to flow in straight lines until a velocity is reached then the streams will waver and commence to break up. The velocity at which this occurs is called the "Critical Velocity". The type of flow in the critical zone is difficult to determine since it consists of both types.

The nature of the flow in a pipeline, whether streamline or turbulent, depends on the **pipe diameter**, the **density** and **viscosity** of the **flowing fluid**, and the velocity of the flow. The numerical value of a dimensionless combination of these four variables is known as the Reynolds number and is used to determine the two types of flow.

1.4 1.4 Reynolds Number

Reynolds number, NR is a dimensionless number which is of great significance because it can be used to determine the type of flow, either streamline or turbulent, which will occur in any pipeline.

$$\text{Reynolds Number is} \quad : \quad N_R = 7740 \frac{dv}{\mu}$$

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Where:

d = pipe inside diameter in inches
v = velocity of flow in ft/sec.
μ = fluid kinematic viscosity in centistokes

Using the Reynolds number, the type of flow can be determined as follows:

N_R < 2000 for streamline or laminar flow
$2000 < N_R$ < 4000 for the critical zone (flow is unpredictable)
N_R > 4000 for turbulent flow

The Reynolds number may also be computed using terms commonly used in pipeline work as follows:

Where:

Q = flowrate in barrels per day
SSU = viscosity in SSU
d = inside diameter of pipe in inches

Streamline flow is a characteristic of low gravity, high viscosity liquids flowing at a low rate. **Turbulent flow** conditions are usually encountered in products pipelines, critical and turbulent flow in crude pipelines except when very viscous liquids are being handled

1.5 1.5 Predicting Pressure Loses in Liquid Pipelines

Two empirical formulas are used more often than any others for predicting pressure loss in single-phase systems. These are the Hazen and Williams formula and the Darcy or Fanning equation.

$$f = 0.2083 \left(\frac{100}{C}\right)^{1.85} \times \frac{q^{1.85}}{d^{4.8655}}$$

Where:

f = friction head in feet of liquid per 100 feet of pipe
c = a constant accounting for surface roughness
q = flowrate in gallons per minute
d = inside diameter of pipe in inches

Graphics and flow charts are available for available for prediction of pressure losses in liquid pipeline based on the Hazen and Williams formula .

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1.6 1.5.2 Darcy or Fanning Equation

A more accurate method for determining the pressure drop in liquid pipelines is to use the Darcy or Fanning equation.

$$h_f = f \frac{L}{D} \frac{V^2}{2g}$$

Where:

h_f = frictional resistence in feet of liquid
L = length of line in feet
D = internal diameter of line in feet
g = gravitational constant : 32.2 ft/sec^2
f = friction factor, dimensionless

However, graphs are available for determination of pressure drop in liquid pipelines based on Darcy or Fanning equation.
Expressed in oil industry units, the liquid head loss equation becomes:

$$hm = \frac{0.13985fQ^2}{D^5} \quad \text{or} \quad Pm = \frac{8.567fQ^2}{D^5\,(131.5 + °API)}$$

Where:

hm = head loss per mile (ft)
f = friction factor, dimensionless
Q = flowrate in barrels per day
D = internal diameter of line in inches
P_m = pressure loss per mile in psi

1.7 1.6 Predicting Pressure Losses in Gas Lines

For estimating pressure drop in short runs of gas piping, Assuming pressure drop through the line is not a significant fraction of the total pressure (i.e. more than 10%).

$$\Delta P_{100} = \frac{W^2}{\rho} \frac{(\ 0.000336f\ )}{d^5}$$

Where

ΔP_{100} = pressure drop, psi/100ft equivalent pipe length
w = mass flow, lb/hr
d = inside pipe diameter, in
f = friction factor

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2. Multiphase Flow

Multiphase vertical flow may be categorised into four different flow configurations or flow regimes, consisting of bubble flow, slug flow, slug-mist transition flow, and mist flow. Complete sets of pressure traverses for specific flow conditions and oil and gas properties have been published by service companies and others. flow types.

Factors Affecting Pressure Losses in Pipelines

∫ Density and viscosity of the fluid

∫ Flowrate or fluid velocity

∫ Pipeline size

∫ Pipeline length

∫ Pipe roughness

∫ Flow restrictions such as valves, chokes and orifices

∫ Pipe fittings and pipeline turns

∫ Changes in elevation

Head Loss in Valves and Fittings

When calculating pressure drop inside flow stations, gas-oil separation plants and production units where valves and fittings are a major part of the hoop-up, it is most helpful to convert pressure drops through these fittings to equivalent length of design size piping. Charts are available for this purpose.

5. Bernoulli's Theorem

The pressure at any point in a system can be determined from Bernoulli's theorem, if the pressure at any other point in the system is known.

This theorem which was derived from conservation of energy, is given by:

$$\frac{P_1}{\rho_1} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_2} + \frac{V_2^2}{2g} + Z_2 + h_f$$

Where:

p	=	pressure
ρ	=	fluid density
v	=	fluid velocity
g	=	gravitational constant
z	=	elevation above a datum
h_f	=	head loss due to friction between points 1 & 2

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Most Common Gas Laws

The total mass of the mixture:

$$m_m = m_A + m_B + m_C + ... = \sum_{i=1}^{k} m_i$$

The mole number of a mixture:

$$N_m = N_A + N_B + N_C + ... = \sum_{i=1}^{k} N_i$$

The mole fraction

$$\frac{mole\ number\ of\ a\ component}{mole\ number\ of\ the\ mixture} = \frac{N_i}{N_m}$$ → Mole fraction y_i

Note that, $\sum_{i=1}^{k} y_i = \sum_{i=1}^{k} \frac{N_i}{N_m} = \frac{1}{N_m} \sum_{i=1}^{k} N_i = \frac{N_m}{N_m} = 1$ therefore: $\sum_{i=1}^{k} y_i = 1$

The mass fraction

$$\frac{The\ mass\ of\ a\ component}{The\ mass\ of\ the\ mixture} = \frac{m_i}{m_m}$$ → Mass fraction m_{fi}

Note that, $\sum_{i=1}^{k} m_{fi} = \sum_{i=1}^{k} \frac{m_i}{m_m} = \frac{1}{m_m} \sum_{i=1}^{k} m_i = \frac{m_m}{m_m} = 1$ therefore $\sum_{i=1}^{k} m_{fi} = 1$

The molecular weight of the mixture can be obtained as:

$$M_m = \frac{m_m}{N_m} = \frac{\sum_{i=1}^{k} M_i N_i}{N_m} = \sum_{i=1}^{k} y_i M_i$$

And the mixture gas constant will be:

$$R_m = \frac{R_U}{M_m}$$

where RU is the universal gas constant (8.314 kJ/kmol K).

Dalton's model

The general form is: $P_m = \sum_{i=1}^{k} P_i \left(T_m, V_m\right)$

General Gas Law

$$PV = ZNR_U T$$

For a mixture, Z_m can be computed as: $Z_m = \sum_{i=1}^{k} y_i Z_i$

Units	R
Atm.cc/g-mol °K	82.06
Btu/lb-mol °R	1.987
Psia cuft/lb-mol °R	10.73
Psia cuft/lb-mol °R	1544
Atm cuft/lb-mol °R	.73
mm Hg cuft / lb-mol °R	62.37
In Hg lit/g-mol °R	21.85
Cal/g-mol °K	1.987
Kpa m³ /kg-mol °K	8.314
J/ kg-mol °K	8314

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Remember that: $y_i = \frac{mole\ number\ of\ a\ component}{mole\ number\ of\ the\ mixture} = \frac{N_i}{N_m}$

Pseudo pressure: $P'_{cr,m} = \sum_{i=1}^{k} y_i P_{cr,i}$

$P_{cr,I}$ is the critical pressure for each component of the mixture.

Pseudo temperature: $T'_{cr,m} = \sum_{i=1}^{k} y_i T_{cr,i}$

$P_{cr,I}$ is the critical temperature for each component of the mixture.

Specific Gravity

$$\gamma = \left(\frac{\rho_{gas}}{\rho_{air}}\right)_{s.c.} = \left(\frac{M_{gas}}{M_{air}}\right)$$

- A substance that is heavier than water $\longrightarrow$ has a higher specific gravity $\longrightarrow$ lower specific volume.
- A substance that is lighter than water $\longrightarrow$ has a lower specific gravity $\longrightarrow$ higher specific volume.

Weight of equal volume of water x specific gravity of liquid

To calculate the weight of a liquid when given its volume and specific gravity:

$$\text{Volume of liquid} = \frac{\text{Volume of equal weight of water}}{\text{Specific gravity of liquid}}$$

Reduced Pressure and Temperature

Reduced pressure and temperature are also called pseudocritical pressure and temperature, expressed as

$$p_r = p_{pr} = \frac{p}{p_c}$$

$$T_r = T_{pr} = \frac{T}{T_c}$$

Key's Rule is used to obtain the critical pressure and temperature for natural gas mixtures

$$p_c = \sum_i p_{ci} y_i$$

$$T_c = \sum_i T_{ci} y_i$$

Gas Density

Need molecular weight, z-factor and the local temperature and pressure.

$$\rho = \frac{pM}{zRT}$$

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Friction Factor and Reynolds Number

The friction factor in commercial pipes can be calculated from the Haaland equation

$$\frac{1}{\sqrt{f}} = -\frac{1.8}{n}\log\left[\left(\frac{6.9}{\text{Re}}\right)^{n} + \left(\frac{k}{3.75d}\right)^{1.11n}\right]$$

where n = 3 for natural gas pipelines (n = 1 for liquid flow). The Reynolds number is give by

$$\text{Re} = \frac{\rho u d}{\mu}$$

and the relative roughness by *k/d*.

Pressure Drop Horizontal Pipeline

Darcy-Weisbach equation

$$\Delta p_f = \frac{f}{2}\frac{L}{d}\rho u^2$$

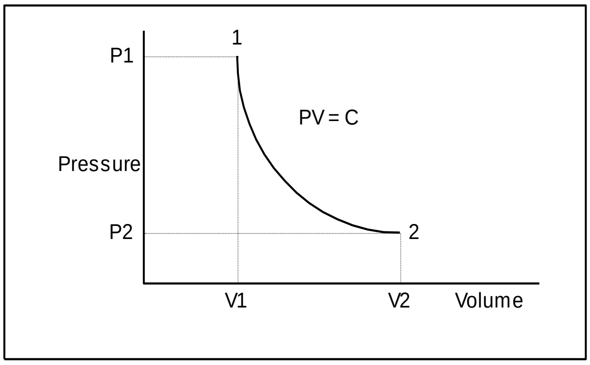
where average gas properties are used.

Boyle's Law

PV = const. or $P_1/P_2 = V_2/V_1$ or $P_1V_1 = P_2V_2$

Where :

P	Absolute pressure
V	Volume
P_1 & V_1	(original conditions)

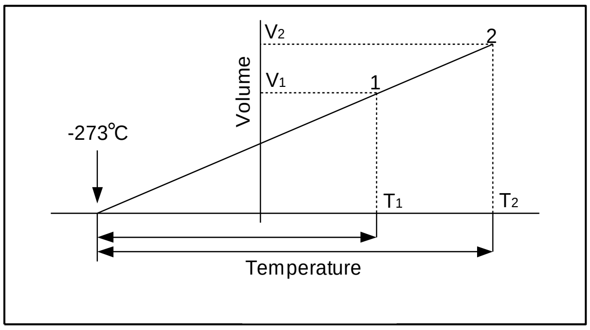


Charlie's Law

1- T/V = const. or V1/V2=T1/T2 or T1/V1=T2/V2

2- T/P = const. or P1/P2 = T1/T2 or T1/P1 = T2/P2

Where T is absolute temperature



Avogadro's Law

Which states that under the same conditions of temperature and pressure equal volumes of all ideal gases contain the same number of molecules?

It has been shown that there are 2.733 * 1026 molecules in pound mole of any gas

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Fluid Measurements Devices

Major Process Variables

(Flow – Pressure – Temperature – Level)

Fluid Flow Measurements

The most common principals for fluid flow metering are:

- **Differential Pressure Flowmeters**
- **Velocity Flowmeters**
- **Positive Displacement Flowmeters**
- **Mass Flowmeters**
- **Open Channel Flowmeters**

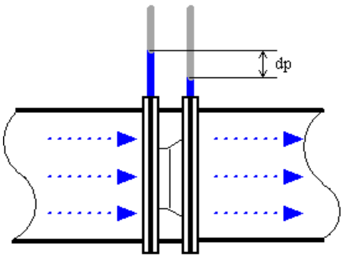
Differential Pressure Flowmeters

In a differential pressure drop device the flow is calculated by measuring the pressure drop over an obstructions inserted in the flow. The differential pressure flowmeter is based on the Bernoulli's Equation .

Common types of differential pressure flow meters are:

- Orifice Plates
- Flow Nozzles
- Venturi Tubes
- Variable Area - Rotameters

Orifice Plate



With an orifice plate, the fluid flow is measured through the difference in pressure from the upstream side to the downstream side of a partially obstructed pipe. The plate obstructing the flow offers a precisely measured obstruction that narrows the pipe and forces the flowing fluid to constrict.
The Turn Down Rate for orifice plates are less than 5:1. Their accuracy are poor at low flow rates.

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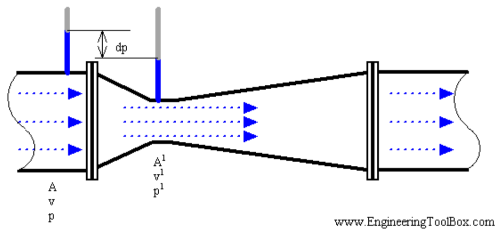
Venturi Tube



Due to simplicity and dependability, the Venturi tube flowmeter is often used in applications where it's necessary with higher TurnDown Rates, or lower pressure drops, than the orifice plate can provide.
In the Venturi Tube the fluid flowrate is measured by reducing the cross sectional flow area in the flow path, generating a pressure difference. After the constricted area, the fluid is passes through a pressure recovery exit section, where up to 80% of the differential pressure generated at the constricted area, is recovered.

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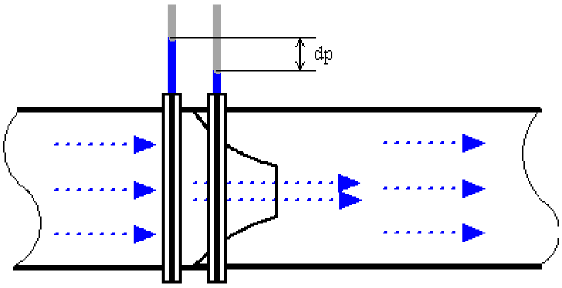
Flow Nozzles

Flow nozzles are often used as measuring elements for air and gas flow in industrial applications.



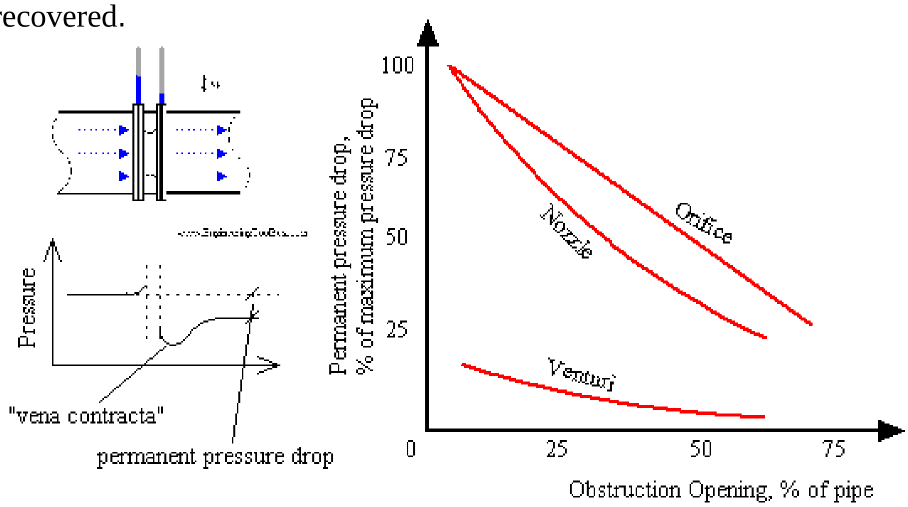
The flow nozzle is relative simple and cheap, and available for many applications in many materials.
The TurnDown Rate and accuracy can be compared with the orifice plate.

The Sonic Nozzle - Critical (Choked) Flow Nozzle

When a gas accelerates through a nozzle, the velocity increase and the pressure and the gas density decrease. The maximum velocity is achieved at the throat, the minimum area, where it breaks Mach 1 or sonic. At this point it's not possible to increase the flow by lowering the downstream pressure. The flow is choked.

Recovery of Pressure Drop in Orifices, Nozzles and Venturi Meters

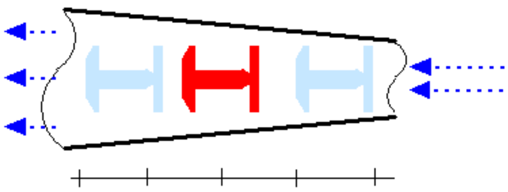
After the pressure difference has been generated in the differential pressure flow meter, the fluid pass through the pressure recovery exit section, where the differential pressure generated at the constricted area is partly recovered.



As we can see, the pressure drop in orifice plates are significant higher than in the venturi tubes.

Variable Area Flowmeter or Rotameter

The rotameter consists of a vertically oriented glass (or plastic) tube with a larger end at the top, and a metering float which is free to move within the tube. Fluid flow causes the float to rise in the tube as the upward pressure differential and buoyancy of the fluid overcome the effect of gravity.



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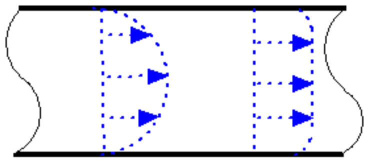
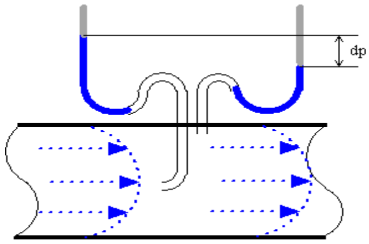
Velocity Flowmeters



In a velocity flowmeter the flow is calculated by measuring the speed in one or more points in the flow, and integrating the flow speed over the flow area.

Pitot Tubes

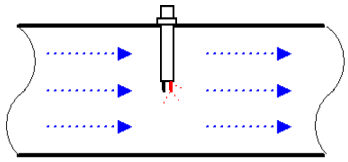
The pitot tube are one the most used (and cheapest) ways to measure fluid flow, especially in air applications like ventilation and HVAC systems, even used in airplanes for speed measurent.



The pitot tube measures the fluid flow velocity by converting the kinetic energy of the flow into potential energy.

The use of the pitot tube is restricted to point measuring. With the "annubar", or multi-orifice pitot probe, the dynamic pressure can be measured across the velocity profile, and the annubar obtains an averaging effect.

Calorimetric Flowmeter



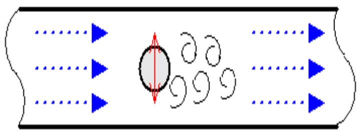
The calorimetric principle for fluid flow measurement is based on two temperature sensors in close contact with the fluid but thermal insulated from each other.

The calorimetric flowmeter can achieve relatively high accuracy at low flow rates.

Turbine Flowmeter

There is many different manufacturing design of turbine flow meters, but in general they are all based on the same simple principle:
If a fluid moves through a pipe and acts on the vanes of a turbine, the turbine will start to spin and rotate. The rate of spin is measured to calculate the flow.
The turndown ratios may be more than 100:1 if the turbine meter is calibrated for a single fluid and used at constant conditions. Accuracy may be better than +/-0,1%.

Vortex Flow Meter



An obstruction in a fluid flow creates vortices in a downstream flow. Every obstruction has a critical fluid flow speed at which vortex shedding occurs. Vortex shedding is the instance where alternating low pressure zones are generated in the downstream.

Electromagnetic Flowmeter

An electromagnetic flowmeter operate on Faraday's law of electromagnetic induction that states that a voltage will be induced when a conductor moves through a magnetic field. The liquid serves as the conductor and the magnetic field is created by energized coils outside the flow tube.

The voltage produced is directly proportional to the flow rate. Two electrodes mounted in the pipe wall detect the voltage which is measured by a secondary element.
Electromagnetic flowmeters can measure difficult and corrosive liquids and slurries, and they can measure flow in both directions with equal accuracy.

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Ultrasonic Doppler Flowmeter

The effect of motion of a sound source and its effect on the frequency of the sound was observed and described by Christian Johann Doppler.
The frequency of the reflected signal is modified by the velocity and direction of the fluid flow
If a fluid is moving towards a transducer, the frequency of the returning signal will increase. As fluid moves away from a transducer, the frequency of the returning signal decrease.
The frequency difference is equal to the reflected frequency minus the originating frequency and can be use to calculate the fluid flow speed.

Positive Displacement Flowmeter

The positive displacement flowmeter measures process fluid flow by precision-fitted rotors as flow measuring elements. Known and fixed volumes are displaced between the rotors. The rotation of the rotors are proportional to the volume of the fluid being displaced.
The number of rotations of the rotor is counted by an integral electronic pulse transmitter and converted to volume and flow rate.
The positive displacement flowmeter may be used for all relatively nonabrasive fluids such as heating oils, lubrication oils, polymer additives, animal and vegetable fat, printing ink, freon, and many more.
Accuracy may be up to 0.1% of full rate with a TurnDown of 70:1 or more.

Mass Flowmeters

Mass meters measure the mass flow rate directly.

Thermal Flowmeter

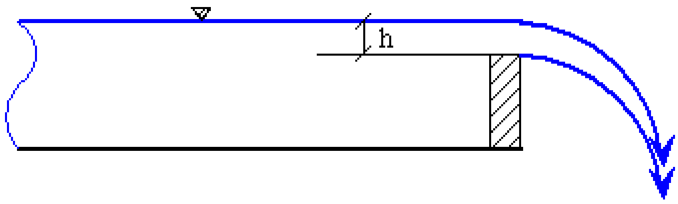
The thermal mass flowmeter operates independent of density, pressure, and viscosity. Thermal meters use a heated sensing element isolated from the fluid flow path where the flow stream conducts heat from the sensing element. The conducted heat is directly proportional to the mass flow rate and the he temperature difference is calculated to mass flow.
The accuracy of the thermal mass flow device depends on the calibrations reliability of the actual process and variations in the temperature, pressure, flow rate, heat capacity and viscosity of the fluid.

Coriolis Flowmeter

Coriolis Mass Flowmeter uses the Coriolis effect to measure the amount of mass moving through the element. The fluid to be measured runs through a U-shaped tube that is caused to vibrate in an angular harmonic oscillation. Due to the Coriolis forces, the tubes will deform and an additional vibration component will be added to the oscillation. This additional component causes a phase shift on some places of the tubes which can be measured with sensors.
The Coriolis flow meters are in general very accurate, better than +/-0,1% with an turndown rate more than 100:1. The Coriolis meter can also be used to measure the fluids density.

Open Channel Flowmeters

A common method of measuring flow through an open channel is to measure the height of the liquid as it passes over an obstruction as a flume or weir in the channel.



Common used is the Sharp-Crested Weir, the V-Notch Weir, the Cipolletti weir, the Rectangular-Notch Weir, the Parshall Flume or Venturi Flume.

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Level Measurement

There are Two Methods To Measure the Level of the Liquid :

- ☒ **Direct Methods**
- ☒ **Indirect or inferential Methods**

Direct Methods (Visual Methods)

- ✓ **Dip stick & Dip Rods**
- ✓ **Weighted Gauge Tape**
- ✓ **Sight Glasses**
  - **The Flat Glass Tubular (or reflex)**
  - **Magnetic**
- ✓ **Floats**

Indirect Methods (Inferential Methods)

Use The Changing Position Of The Liquid Surface to determine level with reference to a datum line. It can be used for low & High levels where use of direct method instruments is identical

Hydrostatic Pressure Methods

Level measurement involving the principles of hydrostatics has been available for many years . these gauges have taken numerous forms , including :

- ✓ **The Diaphragm – box system**
- ✓ **Hydrostatic Differential Pressure Meters**
- ✓ **The air Bubble tube or purge system**

Displacement Devices

The displacement level transmitter is commonly used for continuous level measurement. It works on the buoyancy principle.

Sonic and Ultra Sonic Level Sensors

In Applications where it's not acceptable for the level measuring instrument to come into contact with the process material , sonic or ultra sonic device can be used these devices measure the distance from a reference point in the vessel to the level interface , using sonic or ultra sonic waves .

Radiation Type Instruments

The three common radiation type level instruments – Nuclear, Microwave and Radar . These Systems can be used to detect level on a wide variety of products , from liquids to bulk solids and slurries .

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Temperature Measurement

- ☒ Bimetal
- ☒ Filled System
- ☒ Radiation Pyrometery
- ☒ Thermistors
- ☒ Thermocouples
- ☒ Rtds

Pressure Measurement

- ☒ Manometers
- ☒ Mechanical Transducers
- ☒ Bourdon Element
- ☒ Bellow Elements
- ☒ Diaphragm Elements
- ☒ Electronic Transducer
- ☒ Strain Gauges
- ☒ Variable Reluctance
- ☒ Variable Capacitance

Miscellaneous Measurement

- ☒ Gas Analysis
- ☒ Liquid Analysis
- ☒ Weight Measurement
- ☒ Vibration Measurement
- ☒ Axial Displacement Measurement
- ☒ Speed Measurement

Chapter 4

Plant Equipment Over view

نظرة عامة عن المعدات

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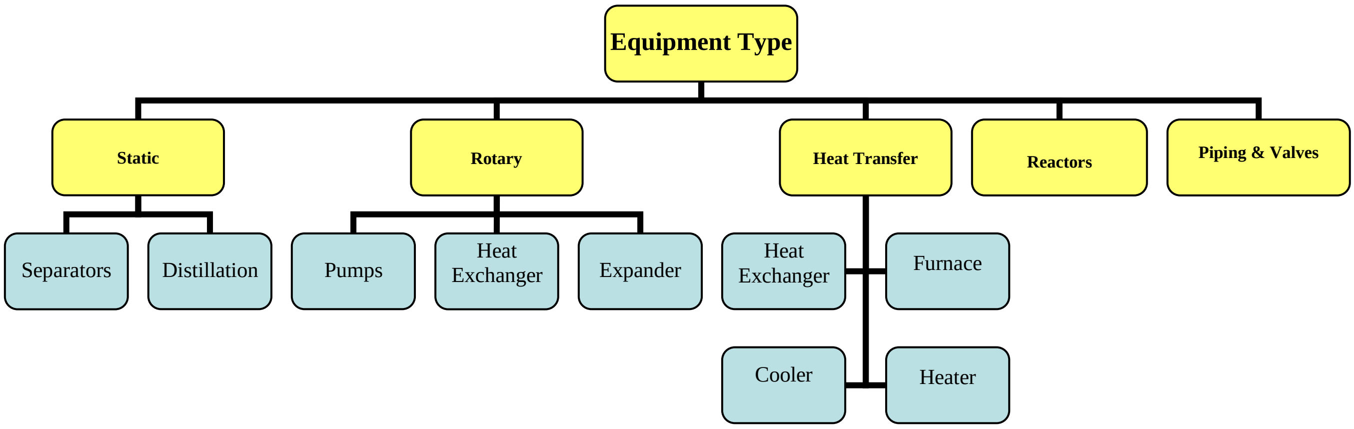
Plant Equipment



Static Equipment

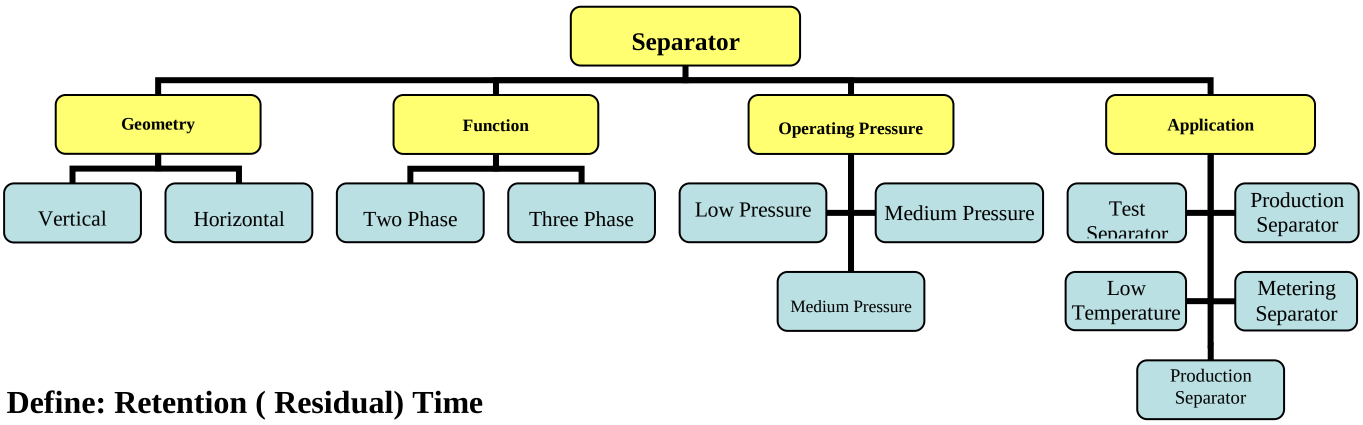
A- Separators:

Are mechanical devices used for primary separation to remove and collect liquid from natural gas, which is normally accomplished with the aid of centrifugal force

Phase separation of the production stream is usually performed as soon as is conveniently possible because:

- **It is technically easier and less costly to process the gas, crude oil, and produced water phases separately.**
- **The produced water is often corrosive. Therefore, removing the water reduces corrosion damage.**
- **Less energy is required to move the separated single phases; so phase separation permits the back pressure to be lowered and this, in turn, increases well production**

Separator Classifications



Define: Retention (Residual) Time

The amount of time a liquid stays in a vessel. *The retention time assures that equilibrium between the liquid and gas has been reached at separator pressure*. The retention time in a separator is determined by dividing the liquid volume inside the vessel by the liquid flow rate. The retention time usually varies between 30 seconds and 3 minutes. If a foaming crude is present, the retention time could be increased by four times its normal values

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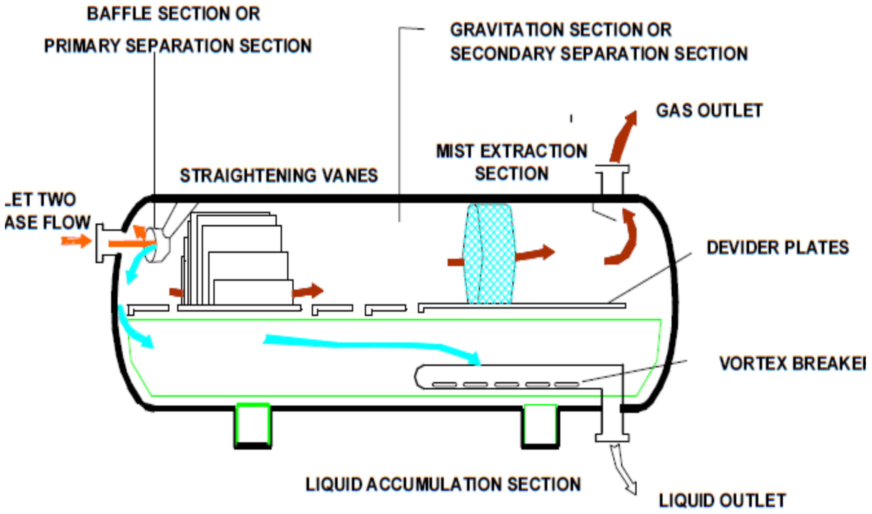
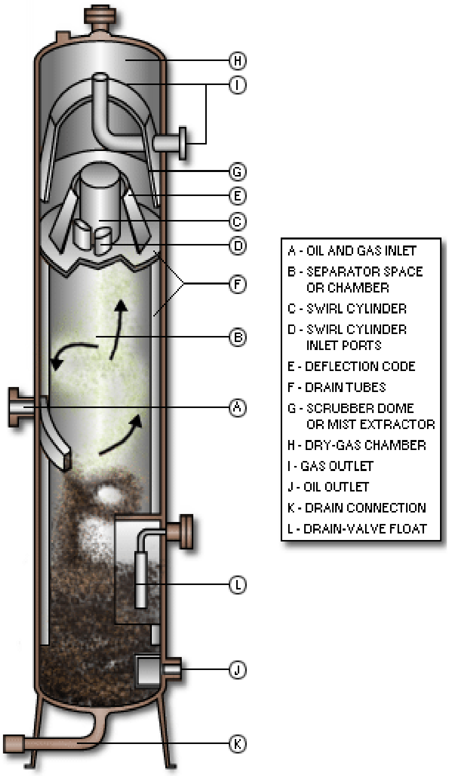
Separator Drawing With Components





Separator Components Functions

Internal Device	**Purpose of Device or Situation & where Device should not be used**
1- Mist Pad	**a- remove liquid mist from gas.**
	b- break oil-water emulsion.
	c- not used where hydrate, wax, or dirt may be present.
2- Deflector Plate	**a- separate liquid from gas.**
	b- used in all services.
3- Coalescing Plate	**a- remove liquid mist from gas.**
	b- separate oil from water.
	c- not used where hydrate, corrosion, wax or dirt present.
4- Straightening Vanes	**a- remove liquid mist from gas.**
	b- separate oil from water.
	c- not used where hydrate, corrosion, wax or dirt present.

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Internal Device	Purpose of Device or Situation & where Device should not be used
5- Filter Elements	a- Remove solid particles from gas or liquid.
	b- Separate oil from water.
	c- Remove mist from gas.
	d- Not used where wax or hydrate may be present.
6- Coalescing Materials	a- separate oil from water.
	b- not used where wax may be present.
7- Centrifugal Devices	a- separate gas from liquid.
	b- not used where wax or dirt may be present.
	c- not used with intermittent gas flow.
8- Horizontal Baffles	a- usually used in large gas-liquid vessels where waves occur.
9- Vortex Breakers	a- should be used on all liquid outlet nozzles in gas-liquid separators
	b- are not needed if vessel is full of liquid
10- Float Shield	a- should be used when internal level control float is used.
11- Water Jets and Sand Cones	a- used only when solids may be present.

Selection of separator

Vertical Separator

1. Well fluids having a high liquid/gas ratio.

2. Well fluids containing appreciable quantities of sand, mud, and similar finely divided solids.

3. Installations with horizontal space limitations but with little or no vertical height limitations

4. Upstream of other field process equipment that will not perform properly with entrained liquid in the gas.

5- Where economics favors the vertical separator

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Horizontal Separator

1. **Liquid/liquid separation in three-phase separator installations to obtain more efficient oil/water separation.**
2. **Separating foaming crude oil where the larger liquid/gas contact area of the horizontal vessel .**
3. **Installations where vertical height limitations indicate the use of a horizontal vessel.**
4. **Well fluids with a high GOR.**
5. **Well with relatively constant flow rate and with little or no liquid heading or surging.**
6. **Where portable units (either skid or trailer mounted) are required for either test or production**
7. **Where economics favors the horizontal separators.**

Spherical Separator

1. **Well fluids with high GOR's, constant flow rate and no liquid slugging or heading.**
2. **Installations where both vertical and horizontal space and height limitations exist.**
3. **Downstream of process units such as glycol dehydrators and gas sweeteners to scrub expensive process fluids, such as glycol .**
4. **Installations where economics favors the spherical separator.**

Troubleshooting

- ☒ **Mist going out gas line**
  - **Vessel too small.**
  - **Plugged mist extractor.**
  - **Improper liquid level (too high or too low).**
- ☒ **Foaming problem.**
  - **Free gas going out oil valve**
  - **Too low level in separator.**
  - **Dump valve not seating.**
  - **No vortex breaker or breaker plugged or damaged.**
- ☒ **Condensate and water not separating in 3-phase separator**
  - **Adjustable weir out of adjustment.**
  - **Not enough retention time..**
  - **Leak in adjustable weir.**
- ☒ **Diaphragm operated dump valve not opening**
  - **Supply gas failure**
  - **Broken valve stem.**

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Separators Notes :

1- separators normally have the following components or features:

- ***Primary Separation Section.*** For collecting and removing the bulk of the liquid in the inlet stream. Some form of inlet baffling is usually used to exploit the momentum of the inlet stream either by creating centrifugal force (as in vertical separators) or an abrupt change of direction (as in horizontal separators) thus separating most of the incoming liquid.
- ***Secondary or Gravity Settling Section.*** Here the gas velocity and turbulence is reduced so that entrained liquid drops can settle out by gravity. Internal baffling is often used to dissipate foams, further reduce turbulence, and accelerate drop removal.
- ***Mist Extraction or Coalescence Section.*** The mist extractor, which can consist of a series of vanes, a woven wire mesh pad, or a centrifugal device, removes small droplets (normally down to 10 micron diameter) of liquid from the gas stream before the gas leaves the vessel. Liquid carry-over often meets a 0.1 gallon per MMscf spec.

2- Production Separator

- A production separator is used to separate the produced well fluid from a well, group of wells

3- Test Separator

- A test separator is used to separate and to meter the well fluids.
- They can be permanently installed or portable (skid or trailer mounted).

4- Expansion Vessel

- This name applied to the vessel into which gas is expanded for a cold separation application. It also is referred to as a cold separator or a low temperature separator. it is designed primarily to handle and melt gas hydrates that are formed by expansion cooling.

5- Scrubber

- Scrubbers are usually two-phase, vertical vessels. The scrubber is NOT used as a primary separation means at a well, and are recommended only for :Flare Scrubbers , Fuel Gas Scrubbers
- Secondary operation to remove carryover fluids from process equipment such as the absorber

6- Slug Catcher

- Or surge drum is a separator designed to separate bulk liquid-gas flow streams which are surging or slugging. The slug catcher may be also serving as a production separator, in which case better separation is required.

7- Separator Design Factors

- GOR – P & T – Surging & Slugging &Foaming & Corrosive Tendencies – Gas Phys Prop – Impurities Types

Static Equipment

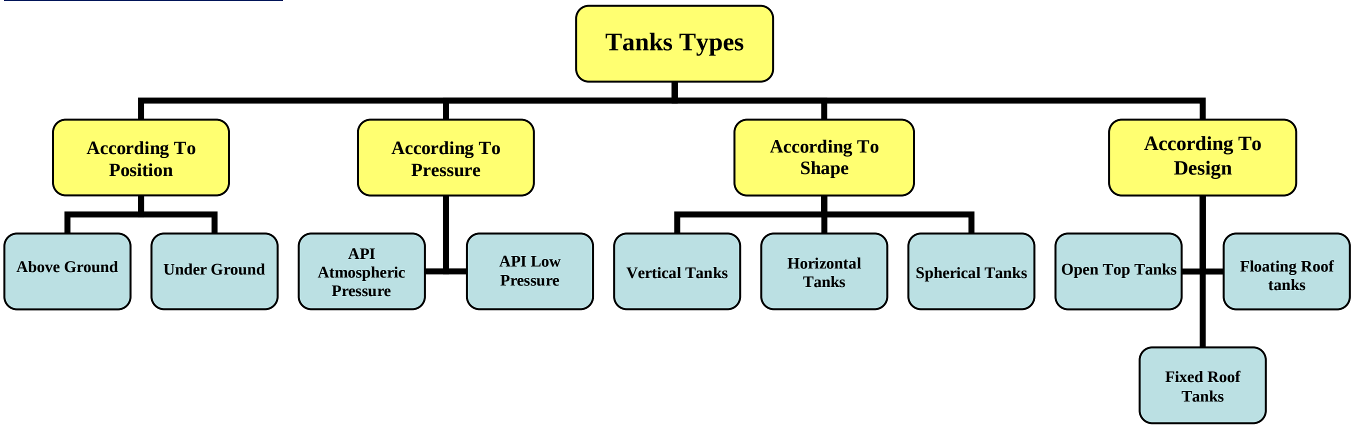
B- Storage Tanks

Tanks are equipment used to store substances; they are widely used in many applications like oil industry, gas processing areas, LPG plants and petrochemical industry.

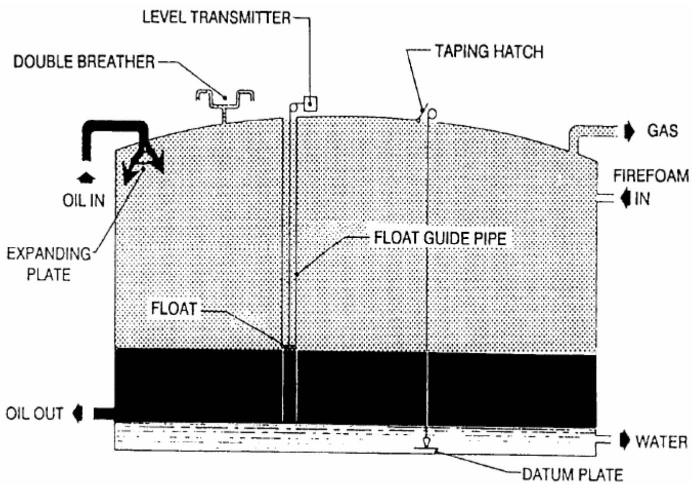
The primary function of a storage tank is to store liquid substance. This liquid substance may be:

- ☒ Feedstock
- ☒ Finished products
- ☒ Unfinished petroleum components waiting for further Processing

Tanks Classification



Most Important Points In Tanks



☒ **API atmospheric storage tanks:**

- Supported cone roof
- Self-supporting fixed roof
- Floating roof
- Fixed roof with internal floating roof

☒ **API Low-Pressure Storage Tanks**

- Single-walled
- Double-walled
- Spheroidal
- Spherical

☒ **Vertical tanks.**

The vertical tanks are the widest applied in petroleum field because it rather than another types in design, construction and maintenance jobs, Because it's bottom, shell and roof are nearly straight.

☒ **Advantages and Disadvantages Of Horizontal Storage :**

☒ **Advantages**

- It can put under or over ground and this can lead to use the area over the tank without any serious.
- Putting it under ground is consider self-insulation from ambient heat and this can reduce vaporization
- It can fabricated as complete unit and transfer it to using site

☒ **Disadvantages**

- These disadvantages are concerned by using it under ground because there are some problems as:
- More corrosion can occur because the contact between tank body and soil.
- The difficulty to perform the maintenance jobs which lead to ring it out the ground.

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☒ Open top tanks

This type of tank has no roof and shall be used for storing city water, fire water and cooling water

floating roof tanks

Operate at internally pressure slightly above atmospheric pressure (3 psi)

A Floating roof on an oil-storage tank has two principal functions:

To minimize evaporation loss
To reduce fire hazard.

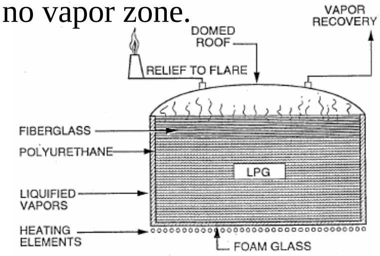
Causes for vapors emissions

(1) The loss caused by the breathing which accompanies temperature changes.
(2) The loss resulting from the displacement of vapor by liquid when the tank is filled.
(3) The loss occurring when any part of the liquid reaches the boiling temperature.

► floating roof types

(1) Single deck pontoon roof
(2) Double deck roof

The floating roof is used in the tank structure and is floating on the liquid stored within the tank. The floating roof rises and falls with the liquid level within the tank achieving a no vapor zone.



fixed roof tanks

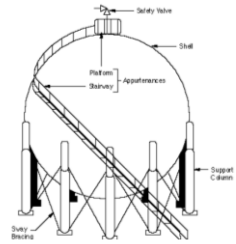
Designed for operating pressure from at mospheric to 15 psi

► Types

(1) Dome Roof Tank
(2) Cone roof tank

The main problem for fixed roof is the space present upward the storage liquid which lead to

1- Product losses
2-oxygen entering to the tank can affect to liquid product



Spherical tanks

Designed for vessels operate above 15 psi

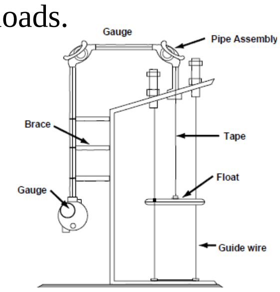
☒ The main differences between a fixed roof tank and a floating roof tank :

- **Oil inlet**
  - This flows from the top for fixed roof tanks and strikes expanding plate to assist in gas Sepration.
  - It flows via the bottom for floating roof tanks.
- **Evaporated gas**
  - Any remaining gas is connected to the low pressure flare for fixed roof tanks.
  - The roof floats on the liquid and eliminates the vapour space above the liquid for floating roof
- **Ventilation**
  - The fixed roof tank is equipped with a double breather valve for pressure to bleed off or for air to suck in.
  - The floating r oof tank is equipped by an automatic bleeder vent.

☒ Sealing

- The fixed roof tank contents can evaporate so a nitrogen blanket is maintained over the liquid surface as a seal.
- Floating roof is sealed to the side of the tank by weights, rubbers or springs loads.

☒ Associated Equipment for Most Tank Types



- Product mixer s and mixing pumps
- Product heaters
- Drains
- Vacuum and pressure relief valves
- Level measuring and sampling devices

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Static Equipment

C- Distillation Tower

Definition :

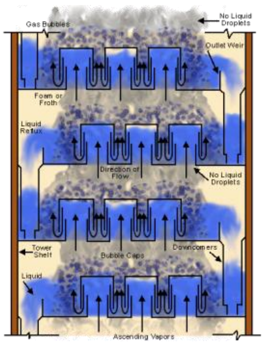
A process in which a liquid or vapour mixture of two or more substances is separated into its component fractions of desired purity, by the application and removal of heat.

Distillation Process Types

- ☒ Batch
- ☒ Continuous

Batch Process
In batch operation, the feed to the column is introduced batch-wise. That is, the column is charged with a 'batch' and then the distillation process is carried out. When the desired task is achieved, a next batch of feed is introduced.

Continuous Columns
In contrast, continuous columns process a continuous feed stream. No interruptions occur unless there is a problem with the column or surrounding process units. They are capable of handling high throughputs andare the most common of the two types. We shall concentrate only on this class of columns.



Types of Continuous Columns

Continuous columns can be further classified according to:

- ☒ The nature of the feed that they are processing,
- ☒ Binary column -feed contains only two components
- ☒ multi-component column -feed contains more than two components
- ☒ The number of product streams they have
- ☒ multi-product column -column has more than two product streams
- ☒ extractive distillation -where the extra feed appears in the bottom product stream
- ☒ azeotropic distillation -where the extra feed appears at the top product stream
- ☒ The type of column internals
- ☒ Tray column -where trays of various designs are used to hold up the liquid to provide better contact between vapor and liquid, hence better separation
- ☒ packed column -where instead of trays, 'packings' are used to enhance contact between vapor and liq .
- ☒ Where the extra feed exits when it is used to help with the separation,

Basic Distillation Equipment And Operation

A typical distillation contains several major components:

- a vertical shell where the separation of liquid components is carried out
- column internals such as trays/plates and/or packings which are used to enhance component Sep .
- a reboiler to provide the necessary vaporization for the distillation process
- a condenser to cool and condense the vapourleaving the top of the column
- a reflux drum to hold the condensed vapourfrom the top of the column so that liquid (reflux) can be recycled back to the column

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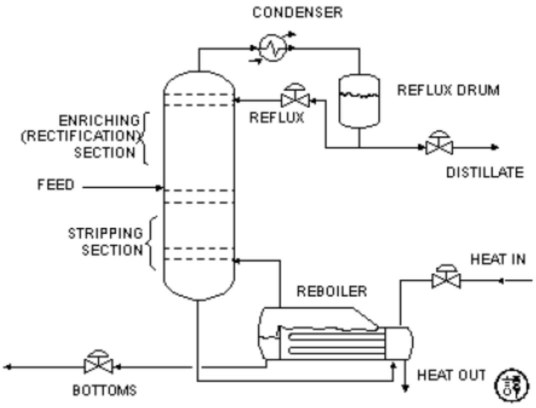
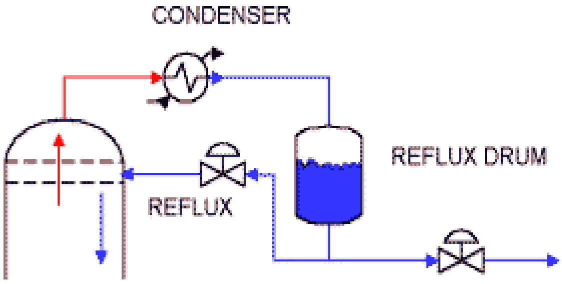
Process Description

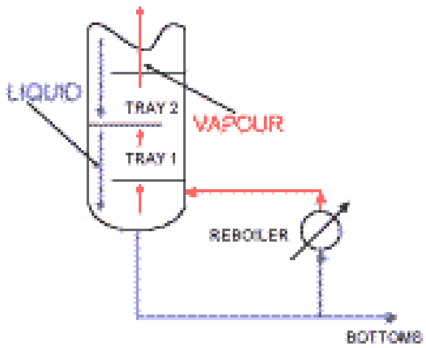
The liquid mixture that is to be processed is known as the feed and this is introduced usually somewhere near the middle of the column to a tray known as the feed tray. The feed tray divides the column into a top (enriching or rectification) section and a bottom (stripping) section. The feed flows down the column where it is collected at the bottom in the reboiler.



Heat is supplied to the reboilerto generate vapor. The source of heat input can be any suitable fluid, although in most chemical plants this is normally steam. In refineries, the heating source may be the output streams of other columns. The vapor raised in the reboiler is re-introduced into the unit at the bottom of the column. The liquid removed from the reboiler is known as the bottoms product or simply, bottoms.



The vapour moves up the column, and as it exits the top of the unit, it is cooled by a condenser. The condensed liquid is stored in a holding vessel known as the reflux drum. Some of this liquid is recycled back to the top of the column and this is called the reflux. The condensed liquid that is removed from the system is known as the distillate or top product.



Column Internals

Trays: stage wise process (used to hold up the liquid to give better separation)

• Sieve
• Valve
• Bubble cap

Packings: continuous process (packed columns are used to enhance contact between vapour & liquid)

• Random packings
•Structured packings

Tray Columns

Basic requirements of tray design:

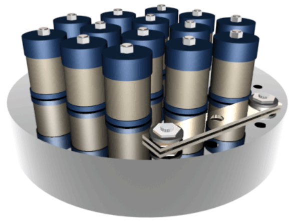
• Intimate mixing between liquid and vapour streams for efficient exchange of components
• Provide sufficient liquid hold-up for high efficiency mass transfer
• Ability to handle desired rates of vapour and liquid flows without excessive liquid entrainment or flooding
• Minimal pressure drop on each tray (especially important in vacuum operation)

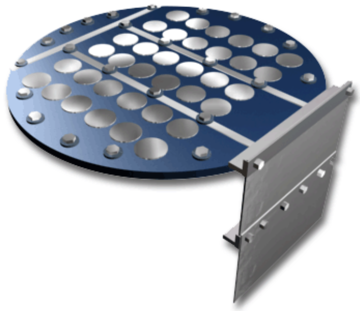
Distillation Trays

Sieve tray: metal, diameter & number of holes are design considerations (cheep and simple)

Bubble Cap tray: has raised chimneys fitted over each holed, a cap covers the riser. There is a space between riser and cap to allow the passage of vapour. The vapour rises through the chimney directed downwards by the cap on discharging through slots in the cap bubbling through the liquid on the tray.

Valve Tray: perforations are covered by lift able caps, self creating a flow area for passage of vapour through the liquid. The lifting caps direct the vapour to flow horizontally into the liquid (better mixing)





Which tray type?

Factors to consider :(Cost – Operation Range / Flexibility – Efficiency)

Generally sieve plates *are satisfactory for many applications (except for low vapor flow rates)*

	Bubble-caps	Valves	Sieves
Relative cost	2.0	1.2	1.0
Pressure drop	Highest	Intermediate	Lowest
Efficiency	Highest	Highest	Lowest
Vapor capacity	Lowest	Highest	Highest
Typical turndown ratio	5	4	2

Packed columns

Packing characteristics in operation:

- Large surface area for maximum vapour/ liquid contact
- High degree of turbulence to promote rapid, efficient mass transfer between phases
- Open structure for low resistance to vapour flow, hence low pressure drops
- Promote uniform liquid distribution on surface
- Promote uniform gas flow across column cross-section

Smaller packing: increased capital cost, higher pressure drop, increased surface area.

Packings- note will need more energy to drive vapour up the column when using packing.

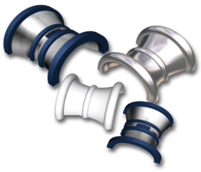
Three types:

- Broken solids; cheapest, hardly used, non-uniformity in size, unreliable performance, high pressure drop
- Shaped packing/ random packing
- Structured packing

Various random shaped packing including:

- **Rasching Rings**: simple hollow ring, oldest, cheapest, most widely used, less effective, not necessarily most economic. Can be made in various material and ceramic and carbon.
- **Lessing Rings**: Rasching Rings with partitions across its centre, increased surface area and strength. Ceramic and metals

• **Pall Rings**: superior performance, highly effective give better wetting and distillation. Liquid smaller pressure drop than Rasching under same conditions, available in metals, ceramics and plastics.
• **Berl saddles**: less free gas space better aerodynamic shape, ceramic or plastic.



Selection of random packing

Need to consider:(Type – Size – Material)

Packings versus Trays

A tray column that is facing throughput problems may be de-bottlenecked by replacing a section of trays with packings. This is because:

- ☒ packings provide extra inter-facial area for liquid-vapor contact
- ☒ efficiency of separation is increased for the same column height
- ☒ packed columns are shorter than trayedcolumns
- ☒ Packed columns are called continuous-contact columnswhile trayedcolumns are called staged-contact columnsbecause of the manner in which vapor and liquid are contacted.
- ☒ Plate towers can be designed to handle a wider range of liquid and gas flow-rates than packed towers.
- ☒ Packed towers are not suitable for very low liquid rates.
- ☒ The efficiency of a tray can be predicted with more certainty than the equivalent term for packing
- ☒ Plate towers can be designed with more assurance than packed towers.
- ☒ It is easier to make provision for the withdrawal of side streams from tray towers.
- ☒ If the liquid causes fouling, or contains solids, it is easier to make provision for cleaning in a tray tower; man ways can be installed on the trays. With small diameter towers it may be cheaper to use packing and replace the packing when it becomes fouled.
- ☒ For corrosive liquids a packed tower will usually be cheaper than the equivalent plate tower.
- ☒ The liquid hold-up is appreciably lower in a packed tower than a plate tower
- ☒ Packed towers are more suitable for handling foaming systems.
- ☒ The pressure drop per equilibrium stage (HETP) can be lower for packing than plates; and packing should be considered for vacuum towers.
- ☒ Packing should always be considered for small diameter towers, say less than 0.6m, where trays would be difficult to install, and expensive .

Towers Functions

Fractionating “Tower”

Is used in referring to a counter-current operation in which a vapor mixture is repeatedly brought in contact with liquid having nearly the same composition as the respective vapors.

Atmospheric Distillation "Tower"

Is the first step in any petroleum refinery, in which the separation of the crude oil into various fractions. These fractions may be products in their own right or may be feed stocks for other refining or processing units.

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Vacuum Distillation "Tower"

Is used to reduce the temperature for the distillation of heat-sensitive materials and where very high temperatures would otherwise be needed to distill relatively non volatile materials.

Stabilization "Tower"

It is a fractionation operation conducted for the purpose of removing high-vapor pressure components.

Splitting "Tower"

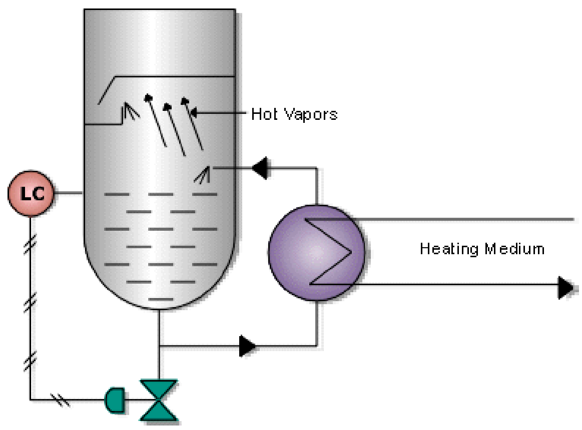
It is a simple distillation process, in which separation of naphtha into two streams before further processing can take place

Stripping "Tower"

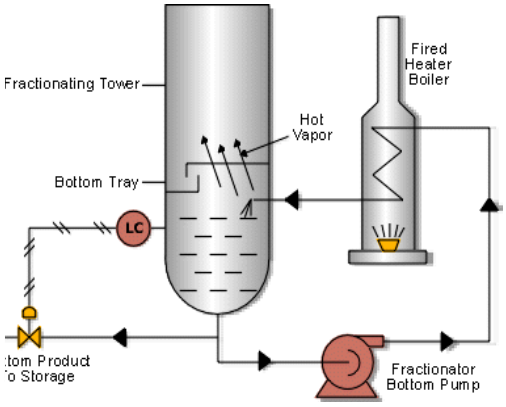
the process where the requirements, to strip a volatile component or group of similar components from a atively non-volatile solution or product by the action of stripping gas or steam.

Column Reboilers

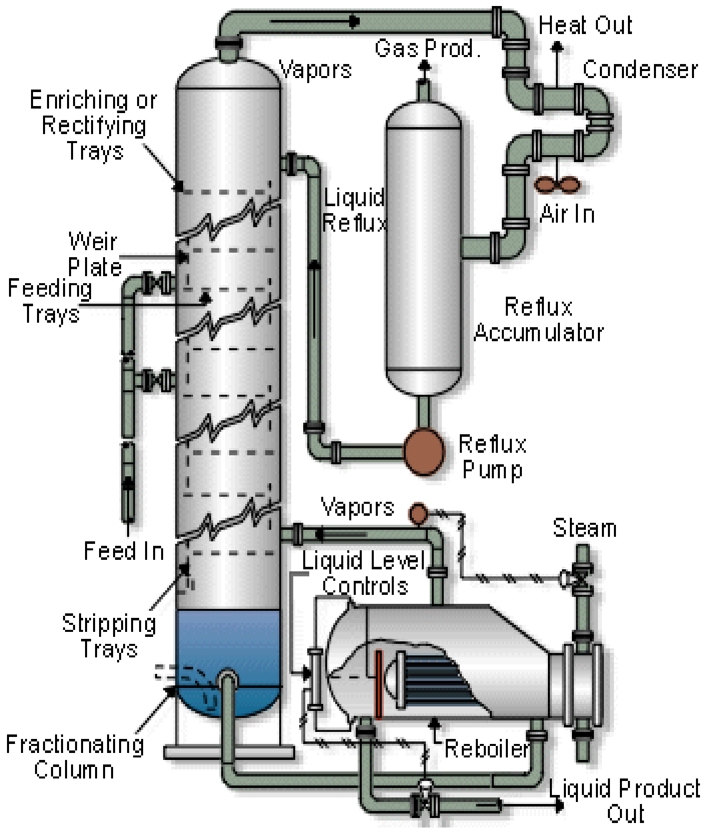
There are a number of designs of re- boilers , they can be regarded as heat exchangers that are required to transfer enough energy to bring the liquid at the bottom of the column to boiling point.



Thermal Syphon Reboiler



Fired Heater Reboiler



Kettle Type Reboiler

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Kettle Type Reboiler :

In this reboiler, the bottom product from the tower flows to the bottom of the reboiler and comes in contact with the hot coils which are heated by steam or another heating medium. Part of the liquid is vaporized and returns back to the tower. It is this hot vapor that passes up through the trays to fractionate the product on each tray. Stated another way, the heat drives the tower. The liquid that is not vaporized passes over the weir plate behind the tube bundle and is level controlled out of the reboiler.

The thermal syphon Reboiler

The thermal syphon reboiler uses convection alone to produce circulation. The bottom product flows to the bottom of the reboiler by gravity. The addition of heat causes some of the liquid in the reboiler to vaporize and the remaining heated liquid expands. The mixture of vapor and hot liquid in the reboiler has a much lower relative density than the bottom liquid and a thermal syphon flow is produced.

Fired Heater Reboiler

The flow through the fired heater type reboiler must be positive to prevent overheating of the tubes in the heater. The fractionator bottom pump circulates allor nearly all, of the bottom product through the reboiler. A positive flow through all passes of the reboiler is very critical and the controls must be interlocked so flow failure will shut down the burners to the heater. In some operations the fired heater will supply heat to more than one fractionator.

Column Condensers

Liquid-vapor contact in the top of the tower is required to purify the overhead product and to condense any bottom product that is being driven overhead. The condensing of someor all, of the overhead product is accomplished by cooling the overhead product in a heat exchanger.

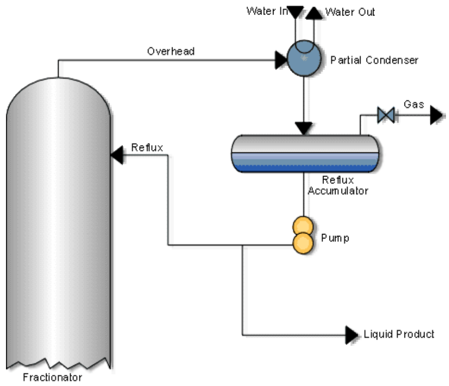
The overhead condenser may use any of the following for a cooling medium:

1. "Fin Fan Cooler", which is a heat exchanger containing finned tubes to increase the heating surface. Air is forced across the tubes by fans, hence the name "Fin Fan".

2. "Water Cooled Condensers", in which the overhead product temperature may be controlled by regulating the flow of cooling water through the condenser. This method may be employed to condense all or part of the overhead product.

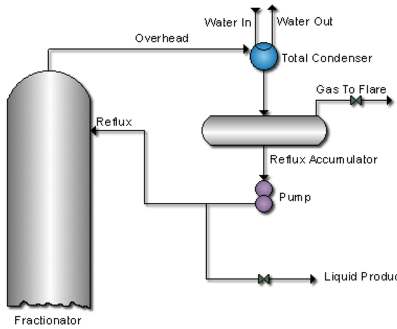
Partial Condensers :

The partial condenser is best used when there is a large difference in the overhead vapor compositions. For example when there is a small amount of methane and hydrogen mixed in a propylene stream, like in the propylene towers. The partial condenser condenses the propylene and leaves the methane and hydrogen as a vapor to be vented from the overhead receiver.



Total Condensers

Total condensers are used to condense all the vapor product coming from the top of the fractionator. The reflux and the condensed product are essentially of the same composition and control is maintained by regulating the amount of cooling medium passing through the condenser. Total condensers are commonly used in condensing LPG and heavier products.



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Hot Vapor By Pass Condenser

The hot vapor by pass condenser is best utilized when there is the potential for large changes of overhead vapor composition. The vapor by pass can be used to maintain the pressure in the tower system when the light components are lower than design. The hot vapor by pass condenser also has a lower installed cost due to the heat exchanger being installed on the ground level.

Column Reflux

The word reflux is defined as "flowing back". Applying it to distillation tower, reflux is the liquid flowing back down the tower from each successive stage.

Kinds of Reflux

A. Cold Reflux

Cold reflux is defined as reflux that is supplied at temperature a little below that at the top of the tower. Each pound of this reflux removes a quantity of heat equal to the sum of its latent and sensible heat required to raise its temperature from reflux drum temperature to the temperature at the top of the tower.

B. Hot Reflux

It is the reflux that is admitted to the tower at the same temperature as that maintained at the top of the tower. It is capable of removing the latent heat because no difference in temperature is involved.

C. Internal Reflux

It is the reflux or the overflow from one plate to another in the tower, and may be called hot reflux because it is always substantially at its boiling point. It is also capable of removing the latent heat only because no difference in temperature is involved.

D. Circulating Reflux

It is also able to remove only the sensible heat which is represented by its change in temperature as it circulates. The reflux is withdrawn and is returned to the tower after having been cooled.

E. Side Reflux

This type of reflux (circulating reflux) may conveniently be used to remove heat at points below the top of the tower. If used in this manner, it tends to decrease the volume of vapor the tower handles.

Reflux Ratio

It is defined as the amount of internal reflux divided by the amount of top product. Since internal hot reflux can be determined only by computation. Plant operators usually obtain the reflux ratio by dividing actual reflux by the top product. It is denoted by R which equals L/D.

The Importance of Reflux Ratio

In general, increasing the reflux improves overhead purity and increases recovery of the bottom product. The number of stages required for a given separation will be dependent upon the reflux ratio used.

Total Reflux

Total reflux is the conclusion when all the condensate is returned to the tower as reflux, no product is taken off and there is no feed.

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At total reflux, the number of stages required for a given separation is the minimum at which it is theoretically possible to achieve the separation and total reflux is carried out at:

- ☒ Towers start-up
- ☒ The testing of the tower

Minimum Reflux

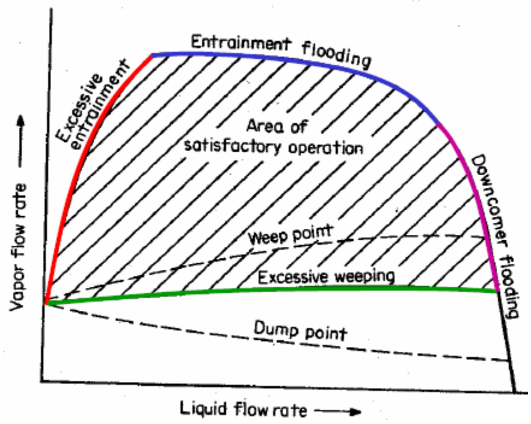
At minimum reflux, the separation can only be achieved with an infinite number of stages. This sets the minimum possible reflux ratio for the specified separation.

Optimum Reflux Ration

Practical reflux ratio will lie between the minimum for the specified separation and total reflux. The optimum value will be the one at which the specified separation is achieved at the lowest annual cost (steam or vapor). For many systems, the optimum value of reflux ratio will lie between 1:2 to 1:5 times the minimum reflux ratio.

Tower Problem Solving

1. Foaming
2. Entrainment
3. Weeping / Dumping
4. Flooding
5. Downcomer / Flooding



Foaming

- ☒ Foaming refers to the expansion of liquid due to passage of vapor or gas, caused by high vapor flow rates.
- ☒ Although it provides high interfacial liquid-vapor contact, excessive foaming often leads to liquid buildup on trays. In some cases, foaming may be so bad that the foam mixes with liquid on the tray above.
- ☒ Whatever the cause, separation efficiency is always reduced.

Entrainment

- ☒ Caused by excessively high vapor flow rates.
- ☒ Entrainment refers to the liquid carried by vapor to the tray above.
- ☒ It is detrimental because tray efficiency is reduced: lower volatile material is carried to a plate holding liquid of higher volatility.
- ☒ Excessive entrainment can lead to flooding.

Flooding

- ☒ Flooding is brought about by excessive vapor flow, causing liquid to be entrained in the vapor up the column.
- ☒ The increased pressure from excessive vapor also backs up the liquid in the downcomer, causing an increase in liquid holdup on the plate above.
- ☒ Depending on the degree of flooding, the maximum capacity of the column may be severely reduced.
- ☒ Flooding is detected by sharp increases in column differential pressure and significant decrease in separation efficiency.

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Weeping/Dumping

- ☒ Caused by excessively low vapor flow.
- ☒ The pressure exerted by the vapor is insufficient to hold up the liquid on the tray. Therefore, liquid starts
- ☒ to leak through perforations.
- ☒ Excessive weeping will lead to dumping - the liquid on all trays will crash (dump) through to the base of the column (via a domino effect) and the column will have to be re-started.
- ☒ Weeping is indicated by a sharp pressure drop in the column and reduced separation efficiency.

Downcomer Flooding

- ☒ Caused by excessively high liquid flow and/or a mismatch between the liquid flow rate and the downcomer area.
- ☒ This can be avoided by ensuring that the downcomer back-up (level) is below 50% of the tray spacing. This can be checked by performing tray sizing using a process simulator.
- ☒ If necessary, design multipass trays (see later).

. *Distillation Important Notes*

☒ ***To Control Tower Temperature:***

- *Reflux Ratio*
- *Temperature Gradient*

☒ ***Reflux Ratio***

- When reflux ratio is increased, the amount of reflux increases. The top product will therefore be purer. In general, the higher the reflux ratio, the fewer the number of trays required for a given separation. However, too high a ratio may cause flooding in the tower resulting in poor separation and causing 'off-spec' products throughout the system. The reflux rate is normally controlled by a temperature controller in the vapour outlet which operates a control valve in the reflux pump discharge. An increase in tower top temperature will cause the valve to open, increasing the reflux rate, and vice versa.

☒ ***Two points to consider***

- A minimum number of plates (stages) required at total reflux.
- There is a minimum reflux ratio below which it is impossible to obtain the *desired*

☒ ***Temperature Gradient***

- if feed and bottom temperatures are too high, too much heavy vapour will rise up the tower and put side-stream products off-spec. This condition, combined with high reflux rate will again lead to flooding and poor separation. Opposite conditions can lead to liquid starvation across the trays and again, a very upset process will result.
- High top temperature will result in heavy components in the overhead product.
- Low top temperature will result in a lighter top product.

☒ ***The operating parameters to be selected by the designer include:***

- Operating pressure
- Reflux ratio
- Feed condition
- feed stage location
- type of condenser

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☒ *How Pressure Control Works*

- Distillation pressure control uses either mass or energy balances around the unit. Mass methods control pressure by regulating the amount of flow into or out of the tower.
- Energy methods regulate the heat flow into and out of the tower.
- In general, mass flow methods control the tower vapor inventory. This may be directly by throttling the vapor rate out of the system or indirectly by manipulating downstream equipment that evacuates gas from the system.
- Energy methods control the heat flux in the overhead condenser.

☒ *Coning*

- Poor vapor-liquid contact occrs due to the vapor forming jets

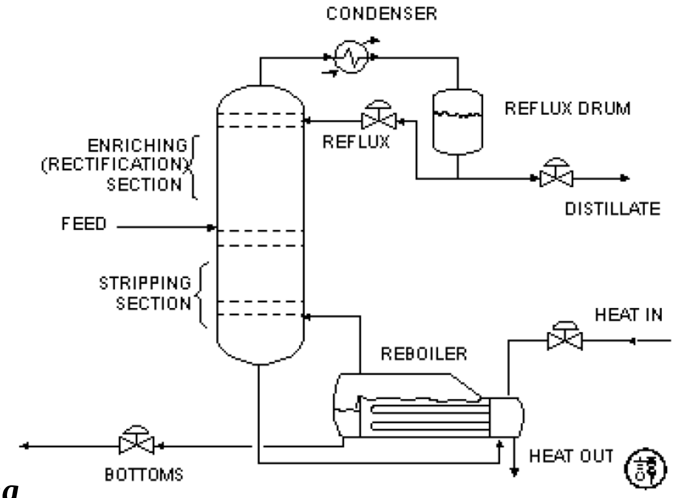
☒ *increasing the number of stages will improve separation..!!!*

☒ *These strangely shaped pieces are supposed to impart good Vapor liquid contact when a particular type is placed together in numbers, without causing excessive pressure drop across a packed section. This is important because a high pressure drop would mean that*

☒ *Distillation Column Design*

- Pease Follow the basis of sizing distillation columns using the McCabe-Thiele graphical design methodology .
- N_{min} This corresponds to total reflux and Nminis determined by Fenske equation
- Please Follow Flash Calculations

☒ *Drwaing Tower over view is very important*



☒ *Troubleshooting*

Case	*Problem*	*Possible solutions*
Separate materials of low molecular mass	Low condensation temperature	Absorption, adsorption, membranes
Separate heat-sensitive materials of high molecular mass	Thermal degradation of products	Vacuum distillation
Separate components present in low concentrations	High flow rates in columns	Absorption, adsorption
Separate classes of components (e.g. aromatics from aliphatics)	Boiling temperatures/volatilities of components in a class are not adjacent	Liquid–liquid extraction
Separate components with similar relative volatilities	Difficult separation: high operating and capital costs	Add mass separating agent and employ extractive or heterogeneous distillation or liquid–liquid extraction, crystallization
Separate components which form an azeotrope	Azeotrope limits product composition	Add mass separating agent and employ extractive or heterogeneous distillation or liquid–liquid extraction, crystallization
Separate volatile and involatile components	Distillation requires that all components are mobile for countercurrent flow	Evaporation, drying, nanofiltration
Separate condensible and noncondensible components	Only partial condenser can be used overhead	Use single-stage separation (flash)

Distillation Questions

1- Distillation is a basic unit operation widely used in oil refineries and petrochemical industries for:
   a) Raising the process pressure
   b) Converting the feed into more valuable products by chemical reactions
   c) Separating products of specific components from a mixture
2- The feed to a vacuum distillation tower is usually:
   a) Gasoline from Atmospheric Distillation Unit
   b) Residue from Atmospheric Distillation Unit
   c) Jet Fuel from Atmospheric Distillation Unit
3- The distillation tower consists of a series of:
   a) Reactors
   b) Trays
   c) Compressors
   d) Reboilers
4- The distillation unit generally consists of a distillation tower, a condenser, a reflux drum and:
   a) A compressor
   b) A reboiler
   c) A turbine
   d) A reactor
5- Within a distillation tower, the liquid leaving the tray is ______in heavier fractions than the vapor leaving the tray.
   a) Leaner
   b) Hotter
   c) Richer
   d) Colder
6- Within a distillation tower, the rising vapor is ___________ in lighter fractions than the liquid in the tray.
   a) Leaner
   b) Hotter
   c) Richer
   d) Colder
7- The bottom product in a distillation tower is:
   a) Relatively pure in heavier components of the mixture
   b) Relatively pure in lighter components of the mixture
   c) Of the same composition as the feed
   d) None of the above
8- On each tray, liquid is heated and therefore, some of the liquid vaporizes. This heat is provided by:
   a) Liquid flowing down from the tray above
   b) Condensation of the vapor coming from the tray below
   c) Reflux
9- In the distillation tower, the lighter components move downwards.
   a) True
   b) False

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10- An example of a tray type is:
a) Bubble Point Tray
b) Bubble Liquid Tray
c) Bubble Cap Tray
d) Bubble Vapor Tray

11- The __________ enters the top of the tray and leaves through the bottom of the tray in a distillation tower.
a) Vapor
b) Liquid

12- In order to maintain adequate amount of liquid within the tower, the vapor leaving the tower is cooled, condensed and returned to the tower. This cooling is achieved by supplying coolant to the:
a) Condenser
b) Distillation tower
c) Reboiler
d) Reflux drum

13- To generate vapor at each tray, heat must be added to the tower. This heat is supplied by the:
a) Reboiler
b) Condenser
c) Pumps
d) Reflux drum

14- The light product is collected from:
a) The tower bottom
b) Near the feed tray
c) The reflux drum

15- The reflux is:
a) Condensed vapor at the top of the tower that is re-circulated back to the tower
b) Liquid feed that is added to the top of the tower
c) Liquid at the tower bottom that is re-circulated back to the tower

16- At the top of the tower, the vapor is cooled and condensed in a condenser, and then collected in the reflux drum. Some of this liquid is re-circulated back to the tower for cooling purposes. This re-circulated liquid is called:
a) Feed
b) Top product
c) Reflux
d) Bottom product

17- An increase in reflux flow to the distillation tower has no effect on the energy consumption.
a) True
b) False

18- In some distillation towers, the reboiler is replaced by sending __________ to the tower.
This __________ the partial pressure of the boiling components.
a) Air / Increases
b) Steam / Decreases
c) Steam / Increases
d) Air / Decreases

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19- Which of the following statements is true?

a) Increase in partial pressure of boiling components lowers the mixture boiling point.
b) Decrease in partial pressure of boiling components lowers the mixture boiling point.
c) Change in partial pressure of boiling components does not affect the mixture boiling point.

20- Consider a sealed container with a gas in it.
When the container is heated, the pressure:

a) Increases
b) Decreases
c) Does not change
d) None of the above

21- Consider a sealed container with a gas in it. When the container is expanded, the pressure:

a) Increases
b) Decreases
c) Does not change

22- The gas behavior can be approximated by an ideal gas law, PV = nRT, where P: Pressure, V: Volume, n: Number of moles, R: Gas Constant and T: Absolute Temperature.
Suppose there are two sealed containers, A and B, each with identical volumes and at the same temperature, but containing 30 and 10 moles of nitrogen, respectively.
What is the pressure of nitrogen in container A when compared with that in container B?

a) Same
b) Two times
c) Half
d) Three times

23- The gas behavior can be approximated by an ideal gas law, PV = nRT, where P: Pressure, V: Volume, n: Number of moles, R: Gas Constant and T: Absolute Temperature.
Suppose there are two sealed containers, A and B, each with identical volumes and at the same temperature, but containing 10 and 20 moles of nitrogen, respectively.

Suppose the container A is heated until its absolute temperature becomes twice as high as that of B. What is the pressure of nitrogen in container A when compared with that in container B?

a) Same
b) Two times
c) Half
d) Three times

24- Consider a sealed container with pentane in liquid and vapor form, at certain temperature. When the liquid vaporization rate equals vapor condensation rate, the vapor and liquid are said to be:

a) Superheated
b) In equilibrium
c) Subcooled

25- Consider a sealed container with pure component at equilibrium condition.
The pressure exerted by the vapor is called:

a) Vapor pressure
b) Critical pressure

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26- The vapor pressure of a pure component can be determined by its temperature alone.

a) True

b) False

27- If the vapor pressure of a component is higher in a gas mixture.
Then the boiling point of that component is also higher.

a) True

b) False

28- The water boils at approximately 100 deg C (212 deg F) at sea level. The same water boils at a much lower temperature at the top of a mountain due to:

a) Higher vapor pressure of water at higher altitude

b) Lower atmospheric pressure at higher altitude

c) The fact that the thermometer tends to indicate a lower temperature at a higher altitude

29- The boiling point of water and pentane at atmospheric pressure are 100 deg C (212 deg F) and 36 deg C (97 deg F) respectively. Which component has a higher vapor pressure?

a) Pentane

b) Water

c) Cannot say from the above statement

30- Butane boils at – 0.5 deg C (31.1 deg F) at atmospheric pressure.
What is the vapor pressure of butane at 10 deg C (50 deg F)?

a) Higher than atmospheric pressure

b) Lower than atmospheric pressure

c) Cannot say from the above statement

31- Consider a sealed container with two components A and B present in vapor and liquid phases at equilibrium. According to Dalton's Law, the total container pressure is equal to the sum of the vapor pressures of A and B at that temperature.

a) True

b) False

32- If the partial pressure of a component is higher in a gas mixture, then more moles of that component are present in the mixture.

a) True

b) False

33- The partial pressure of a component in a mixture is the pressure exerted by its vapor in the mixture. The partial pressure of a component for a vapor liquid mixture in equilibrium, can be expressed by Raoult's Law

(Partial Pressure) = (Mole Fraction in Liquid) x (Vapor Pressure)

The partial pressure of a component can be calculated by the liquid mole fraction and temperature.

a) True

b) False

34- Consider a sealed container with components A and B present in vapor and liquid phases at equilibrium. Suppose the liquid mole fraction of A and B is 0.5 each.
If the boiling point of A is higher than that of B, compare the partial pressure of A with that of B.

a) A is higher than B

b) A is lower than B

35- Consider a sealed container with components A and B present in vapor and liquid phases at equilibrium. Suppose the liquid mole fraction of A is 0.2 and that of B is 0.8 and the vapor pressure of A is twice as that of B.
The partial pressure of A is:

a) Twice the partial pressure of B
b) Same as the partial pressure of B
c) Half the partial pressure of B
d) Four times the partial pressure of B

36- Consider a sealed container with two Components A and B present in vapor and liquid phases at 66.7 oc (152o F). Suppose the liquid mole fraction of A is 0.5 and vapor pressures of A and B at 66.7 deg C (152 deg F) are 800 mm Hg (31.5 in Hg) and 400 mm Hg (15.8 in Hg) respectively. What is the total gas pressure?

a) 600 mm Hg (23.6 in Hg)
b) 800 mm Hg (31.5 in Hg)
c) 400 mm Hg (15.8 in Hg)
d) 200 mm Hg (7.9 in Hg)

37- The temperature at which the mixture boils is called the "Bubble Point" at its surrounding pressure. The bubble point of a mixture consisting of Components A and B is the temperature at which:

a) The total pressure of the mixture exceeds the surrounding pressure
b) The vapor pressure of A becomes equal to that of B
c) The vapor pressure of A exceeds that of B
d) The partial pressure of A exceeds that of B

38- Suppose a liquid mixture containing equal compositions of one heavy and one light component is partially vaporized. The resultant vapor will contain more of the ___________ component.

a) Light
b) Heavy

39- Consider a vapor mixture consisting of 80% of a lighter component A and 20% of a heavier component B. If all the vapor mixture is condensed, what will be the composition of A and B in the condensed liquid?

a) A is greater than 80% and B is less than 20%
b) A is less than 80% and B is greater than 20%
c) A is 80% and B is 20%

40- Composition control can be used for controlling effective separation of components in a distillation tower.

a) True
b) False

41- Composition of the distilling mixture can be controlled at various sections of the tower by controlling the ____.

a) Temperature
b) Pressure
c) Reflux Drum Level
d) Feed Flow

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42- Normally, the reflux flow controller in a distillation tower indirectly controls the cooling water flow to the condenser.

a) True

b) False

43- Typically, the pressure controller in a distillation tower controls the __________.

a) Pressure of hot oil to the reboiler

b) Pressure of the feed stream to the distillation tower

c) Top pressure of the distillation tower

44- Which of the following statements is true in a distillation tower at a steady state?

a) Feed flow to the tower is the sum of the top product flow and the bottom product flow

b) The top product flow is the sum of the feed flow and the bottom product flow

c) The bottom product flow is the sum of the reflux flow and the feed flow

d) The top product flow and the bottom product are equal

45- The top product flow from a distillation tower is indirectly controlled by the __________.

a) Tower bottom level

b) Reflux drum level

c) Tower pressure

d) Tower temperature

46- The composition of the product of the distillation tower must be controlled to obtain the desired product. Generally, the composition cannot be directly controlled.

Select a process variable which is manipulated to control the product composition.

a) Pressure

b) Reflux drum level

c) Temperature

47- In many distillation towers, the tower temperature is controlled by adjusting the amount of heat to the reboiler. If the tower temperature decreases due to some reason, the temperature controller will __________ the reboiler heat duty to maintain the temperature.

a) Increase

b) Decrease

48- The product composition is regulated by controlling the tower temperature at constant pressure. This is because there is a certain relationship between the tower temperature and composition at a constant pressure.

a) True

b) False

49- When the distillation tower is operated at a higher temperature than normal, the top product:

a) Becomes too heavy

b) Becomes too light

50- In many distillation towers, the tower temperature is controlled by adjusting the reflux flow returning to the tower. If the tower temperature decreases for some reason, the temperature controller will __________ the reflux flow to maintain the temperature.

a) Increase

b) Decrease

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51- The vapor leaving the top of the distillation tower is condensed in the:

a) Reflux Drum
b) By jacketing the vapor line with a coolant
c) Condenser by exchanging heat with cooling water
d) Condenser by exchanging heat with the reflux

52- In the condenser, the vapor leaving the top of the tower is condensed. Some of the condensate returns to the tower and cools the tower. This flow returning to the tower is called:

a) Bottom product
b) Top product
c) Reflux

53- If the tower temperature is maintained constant, a change in the tower pressure does not affect the composition of the products.

a) True
b) False

54- If the pressure of the distillation tower increases, the split range controller ___________ the vapor flow through the condenser bypass line.

a) Increases
b) Decreases

55- When the distillation tower is operated at a lower pressure than normal, the top product:

a) Becomes too heavy
b) Becomes too light

56- The distillation tower temperature is controlled by adjusting the reboiler hot oil flow.

a) True
b) False

57- When the distillation tower temperature is maintained by adjusting the reflux flow:

a) The reboiler heat duty is maintained constant
b) The top product flow is maintained a minimum
c) The bottom product flow is maintained a minimum

58- Prior to commencing the startup operation, it should be ensured that all control valves are fully open.

a) True
b) False

59- During startup operation, as liquid feed is introduced to the distillation tower:

a) The reflux drum level starts increasing
b) Start drawing the top product from the reflux drum
c) The liquid cascades to the bottom of the tower
d) The trays in the tower start separating the components

60- The level at the tower bottom appears:

a) As soon as the feed is introduced
b) When the level at the reflux drum appears
c) Over time after the feed is introduced
d) As soon as the heat is added to the reboiler

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61- During startup operation, start heating the tower through the reboiler:

a) After liquid level is established at the tower bottom

b) Before introducing the feed

c) Immediately after introducing the feed

62- Before you start heating the tower through the reboiler, you must:

a) Start the top product flow

b) Stop the feed flow

c) Introduce coolant to the condenser

d) Fill the reflux drum

63- As a result of fractionation in the tower, the heavier components:

a) Move up the tray

b) Move down the tray

c) Do not move

64- When the reboiler duty decreases, the vapor flow within the tower:

a) Decreases

b) Increases

c) Stays the same

65- The reflux flow is introduced:

a) After the level appears in the reflux drum

b) After the reflux drum becomes almost full

c) Before the level appears in the reflux drum

66- When the reflux flow decreases, the vapor flow within the tower:

a) Decreases

b) Increases

c) Stays the same

67- As the vapor flow decreases, the tower pressure tends to:

a) Increase

b) Decrease

68- When the heat duty to the reboiler is increased, the vapor flow in the tower increases.
The reflux drum level tends to:

a) Increase

b) Decrease

69- In the condenser, the vapor leaving the top of the tower is condensed. Some of the condensate returns to the tower and cools it. This flow returning to the tower is called:

a) Bottom product

b) Top product

c) Reflux

70- When the reflux flow is increased, the vapor flow in the tower decreases and liquid flow increases. The tower bottom level tends to:

a) Increase

b) Decrease

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71- When no feed is supplied to the tower and no products are withdrawn from the tower, the liquid and vapor re-circulate throughout the tower system. This operating condition provides the maximum fractionation effect. This operational mode is called:

a) Partial reflux mode
b) Total reflux mode
c) Normal operating mode

72- Fractionation in a distillation tower is maximum when the tower is in total reflux condition.

a) True
b) False

73- The top and bottom product flows are commenced prior to total reflux operation.

a) True
b) False

74- After the distillation tower is lined to a steady state:

a) Vent some vapor from the tower
b) The top and bottom product flows will be stable
c) Stop cooling water flow to the condenser
d) Stop hot oil flow to the reboiler

75- If the distillation tower is at a steady state, any change in feed composition does not require any change in the tower operating conditions.

a) True
b) False

76- Change in load to the distillation tower refers to:

a) Change in cooling water inlet temperature
b) Change in reboiler hot oil composition
c) Higher condenser or reboiler duty
d) Change in feed flow to the distillation tower

77- Suppose the feed flow is increased and the tower is allowed to reach a new steady state condition. The resultant top product flow will increase and the bottom product flow will:

a) Increase
b) Decrease
c) Stay the same

78- When the liquid throughput within the tower becomes very high, liquid buildup increases on each tray. This buildup eventually leads to the loss of cascading liquid from one tray to another.
The vapor flow from one tray to another is also seriously impeded.
This phenomenon is called:

a) Flooding
b) Weeping
c) Cascading
d) Fluctuating

79- The flooding condition can be recognized by:

a) A significant reduction in product quality
b) A rapid increase in the reflux drum level
c) A rapid increase in the tower temperature
d) A significant drop in the tower pressure

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80- The flooding condition can be identified by:
 a) A rapid increase in the reflux drum level
 b) A higher pressure drop across the tower

81- When flooding occurs, one of the necessary actions is to:
 a) Increase the feed flow rate
 b) Decrease the feed flow rate
 c) Increase the reflux flow rate
 d) Increase the reboiler duty

82- The product compositions can be adjusted by changing the tower temperature or the reflux flow. When the tower temperature is increased, the vapor flow within the tower also increases. Thus, the purity of the bottom product:
 a) Decreases
 b) Increases
 c) Stays the same

83- When the tower temperature is increased, the vapor flow within the tower also increases. As a result, the purity of the top product:
 a) Decreases
 b) Increases
 c) Stays the same

84- When the tower temperature is reduced, the vapor flow within the tower decreases. As a result, the purity of the top product:
 a) Decreases
 b) Increases
 c) Stays the same

85- When the tower temperature is reduced, the vapor flow within the tower decreases. As a result, the purity of the bottom product:
 a) Decreases
 b) Increases
 c) Stays the same

86- When both the reflux flow and the reboiler heat duty are increased, the purity of the bottom product:
 a) Decreases
 b) Increases
 c) Stays the same

87- Suppose that you have to increase the purity of the top product. You must:
 a) Decrease the reflux flow
 b) Increase the reboiler duty
 c) Increase the reflux flow

88- Suppose that you have to increase the purity of the bottom product. You must:
 a) Increase the reboiler duty
 b) Decrease the reboiler duty
 c) Increase the reflux flow

89- The excessively high vapor flow in the tower may lead to:
 a) Explosion of the distillation tower
 b) Entrainment
 c) Excessive condensation of the vapor

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90- When the heat input to the reboiler is increased, the tower temperatures:

a) **Increase**

b) Decrease

91- When the reflux flow is reduced, the tower temperatures:

a) **Increase**

b) Decrease

c) Do not change

92- Consider an increase in the heavier fractions in the feed. As a result, the top product flow:

a) **Decreases**

b) Increases

93- Consider an increase in the lighter fractions in the feed. As a result, the bottom product flow:

a) **Decreases**

b) Increases

94- When the lighter fractions in the feed are increased, the level of the reflux drum:

a) **Increases**

b) Decreases

95- When the lighter fractions in the feed are decreased, the level of the tower bottom:

a) **Increases**

b) Decreases

96- The normal shutdown operation should be taken:

a) As quickly as possible

b) **Gradually**

97- As the feed to the tower is decreased during the normal shutdown operation, the top and bottom product flows are also decreased by automatic control action.

a) **True**

b) False

98- As the reboiler heat duty to the tower is reduced during the normal shutdown operation. the purity of the bottom products:

a) **Decreases**

b) Stays the same

c) Increases

99- As the reboiler heat duty to the tower is stopped, the level of the tower bottom:

a) Decreases

b) **Increases**

100- When are the product draws stopped?

a) Immediately after the initiation of the shutdown operation

b) After the tower is cooled

c) **When the product composition no longer meets the specifications**

101- After the heat to the tower by the reboiler is stopped, the vapor flow in the tower:

a) **Stops**

b) Increases

102- After the feed flow and heat to the tower by the reboiler are stopped, some liquid still remains in the reflux drum and the tower bottom. This liquid is drained to the:

a) **Slop line**

b) Bottom product line

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103- After the tower and drum have been drained completely, they should be purged with:

a) Air
b) Oxygen
c) Nitrogen
d) Hydrogen

104- Loss of feed is not an abnormal condition for distillation tower operation.
The tower operation can continue to operate normally.

a) True
b) False

105- Which of the following is an abnormal condition in a distillation tower.
which may necessitate shutdown of the tower?

a) Tower bottom level sight glass hazy
b) Top product flow indicator shows erratic values
c) Loss of cooling water to condenser

106- When the reflux pump trips during normal operation, you must:

a) Start the backup reflux pump
b) Try to fix the tripped pump while continuing the operation without the reflux pump
c) Commence emergency shutdown immediately

107- When the reflux pump trips during normal operation, the reflux drum level continues to increase and eventually the condenser is flooded. What happens after this situation?

a) The cooling effect of the condenser increases, causing the tower pressure to decrease
b) The cooling effect of the condenser increases, causing the tower pressure to increase
c) The cooling effect of the condenser decreases, causing the tower pressure to increase
d) The cooling effect of the condenser decreases, causing the tower pressure to decrease

108- When the reflux pump trips during normal operation, the control valve of the reflux flow controller:

a) Opens fully
b) Closes fully
c) Stays in the same position

109- When the reflux pump trips during normal operation, the reflux and the top product flows stop. The tower temperature:

a) Decreases
b) Increases

110- When the reflux pump trips during normal operation, the liquid flow in the tower:

a) Increases
b) Decreases

111- When the reflux drum becomes empty during normal operation, the tower temperature:

a) Increases
b) Decreases
c) Stays the same

112- If the reflux drum level transmitter fails by incorrectly sending a level signal much higher than the real level during normal operation:

a) The reflux drum may be filled
b) The level of the tower bottom may increase significantly
c) The reflux drum may become empty

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113- When the reflux drum level transmitter fails by incorrectly sending a level signal much lower than the real level during normal operation, the reflux drum level controller acts to increase the level. The actual level as seen through the field level sight-glass of the reflux drum is:

a) Same as the level shown in the control room
b) Lower than the level shown in the control room
c) Higher than the level shown in the control room

114- When the reflux drum level transmitter fails, the tower may be upset. The corrective action is to:

a) Operate the associated automatic controller in manual mode
b) Continue operating the associated automatic controller in automatic mode
c) Start the shutdown operation

115- When the feed to the tower is lost, a shutdown operation is not required in many cases. The corrective action is to:

a) Reduce the bottom and top product flows
b) Place the tower in total reflux mode
c) Reduce the temperature and pressure to minimize the impact of the feed loss

116- When the feed to the distillation tower is lost, it can be detected by:

a) Feed flow low alarm
b) Lifting of the tower safety valve
c) Loss of cooling water to the condenser
d) Reflux pump trip

117- When the cooling water flow to the condenser is lost, what happens to the tower?

a) The tower temperature decreases slowly
b) No significant change occurs
c) The tower pressure increases rapidly
d) The tower pressure decreases slowly

118- When the cooling water flow to the condenser is lost, what action should be taken?

a) Continue to operate with less feed
b) No action needed, just wait for recovery of the cooling water
c) Place the tower in total reflux mode
d) Shutdown the unit

119- When the cooling water to the condenser is lost:

a) Top product becomes lighter
b) Top product becomes heavier
c) Top product composition is not affected

120- When the cooling water to the condenser is lost, the tower temperatures:

a) Decrease
b) Increase

Rotary Equipment

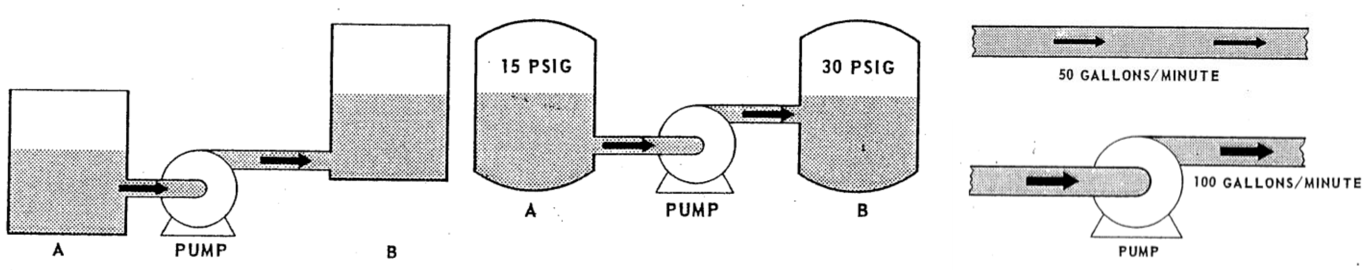
A- Pumps:

The Function Of A Pump

A wide variety of pumps are used in the petroleum industry. A pump is used to increase the total energy content of a liquid in the form of pressure increase. Pumps transfer liquids, for example, between vessels. They are the liquid movers.

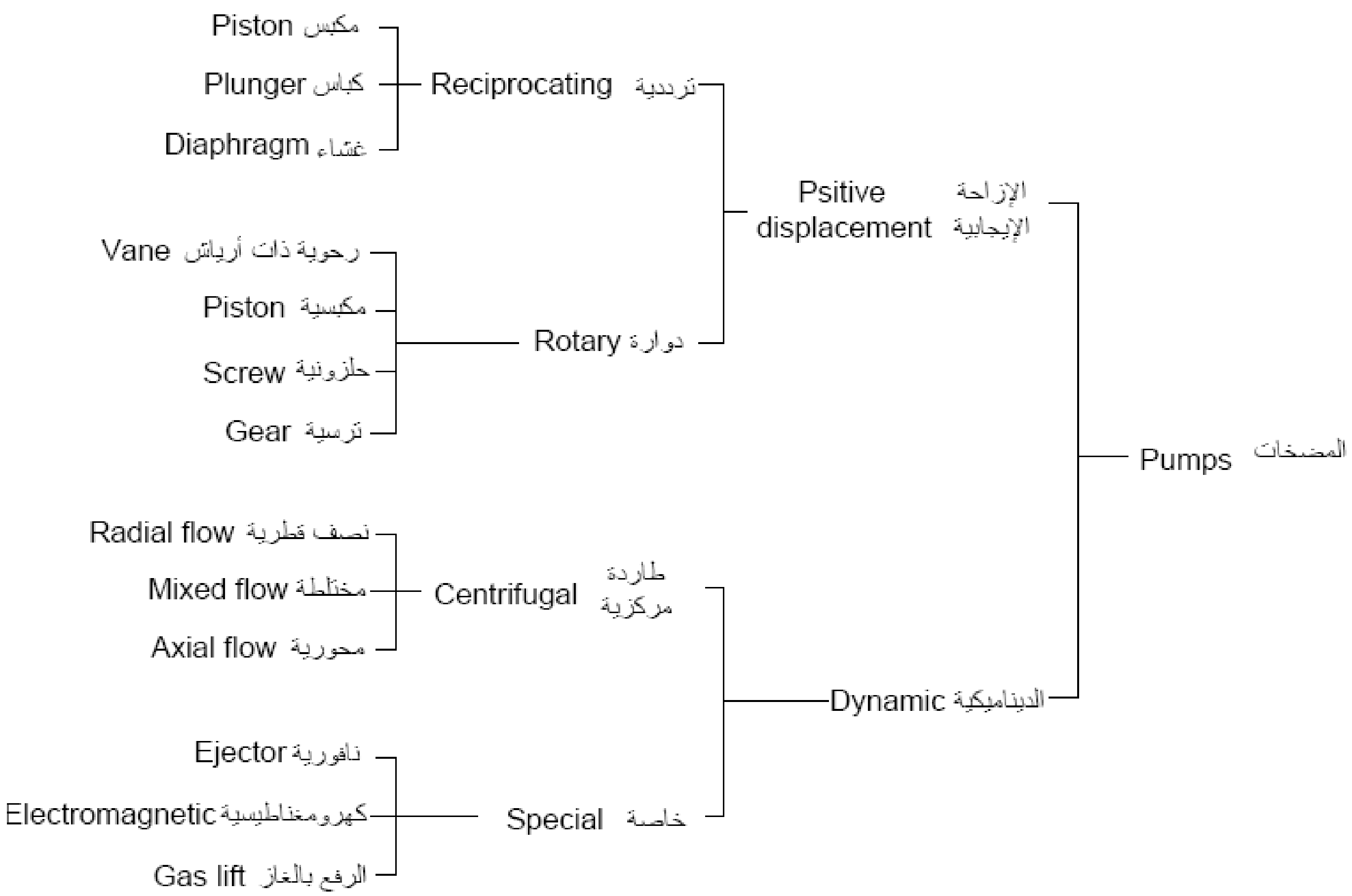
Pumps are used to perform one of the following jobs:

1- Move liquids from low level to high level
2- Move liquids from low pressure location to high pressure location
3- To increase the flow rate of a liquid



Move liquid from low level to high level Move liquid from low pressure Location to high pressure location To increase the flow rate of liquid

Pump Classification



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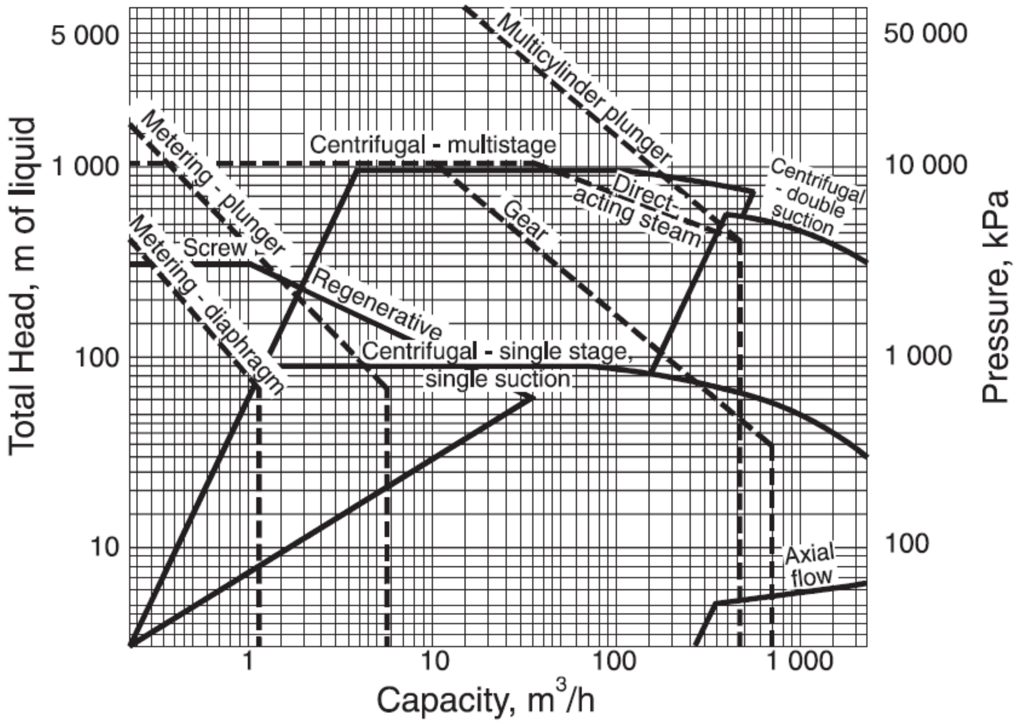
Pump Classification

A- Volumetric (Positive Displacement)

- Reciprocating (Chemical lnj : TEG Circulation, ...)
- Rotating (Lube oil, Viscous fluids, ...)

B- Dynamic (Variable Head)

- Centrifugal (General Process, Liquid Exports, ...)
- Axial (Very high flowrate : Cooling water, ...)

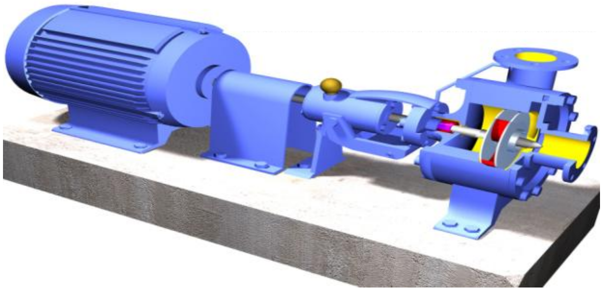


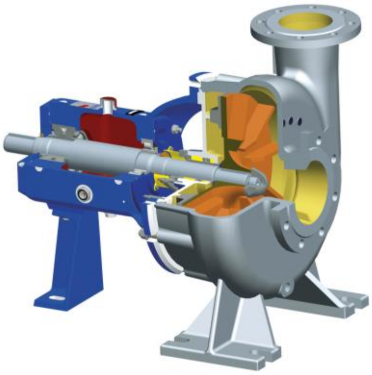
Comparison between PDPS "Positive Displacement Pumps" and "Dynamic "Centrifugal Pump

CRITERIA	PDPS	DYNAMIC PUMPS
Flow rate	Low, typically 100 gpm	As high as 300,000 gpm
Pressure	As high as 300 atm	Moderate, few atm
Priming	Very rarely	Always
Flow Type	Pulsating	Steady
Constant RPM	Constant flow rate for virtually any pressure OR Flow rate cannot be changed without changing RPM ***Hence used for metering***	Head varies with flow rate OR Flow rate changes with head for same RPM
Viscosity	Virtually no effect	Strong effects

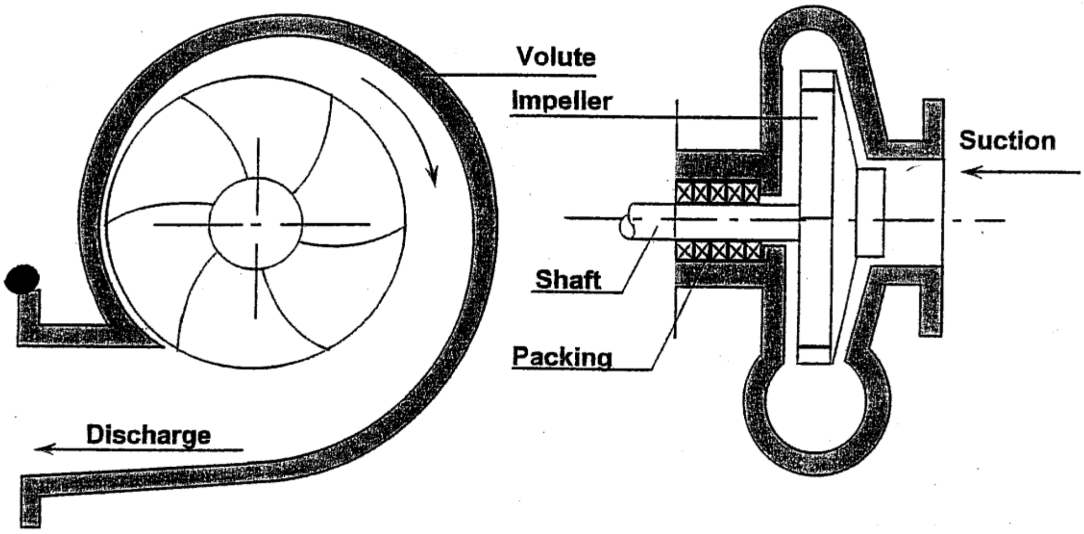
Centrifugal Pump

- **The most common type of pump used in field handling of crude oil.**
- **Centrifugal pumps operate reliably, require low maintenance, and are well-suited for automatic control.**
- **They produce smooth output flow and operate safely against partially closed control Valves safely against a closed valve for short time periods.**
- **Centrifugal pumps operate flexibly over a wide range of flow rates (from a few gpm to 100,000 bpd) at heads ranging from a few psi to 3,000 psi.**





How it Work?
Figure shows the impeller and pump casing of centrifugal pump. Let us see how it works.



1. Liquid flows through the pump inlet and into the eye of the impeller.
2. The impeller whirls the liquid around in a circle. The liquid is forced from the center to the outside of the impeller.
   Centrifugal force pushes the liquid outward from the eye.
3. Liquid enters the pump casing when it leaves the outer edge of the impeller.
   When the liquid enters the casing, speed decreases, as the speed of the liquid decreases, its pressure increases.
4. As centrifugal force moves the liquid away from the impeller eye, a low-pressure area (zone) is formed in the suction eye. This low pressure area in the suction eye causes liquid to flow into the suction eye.

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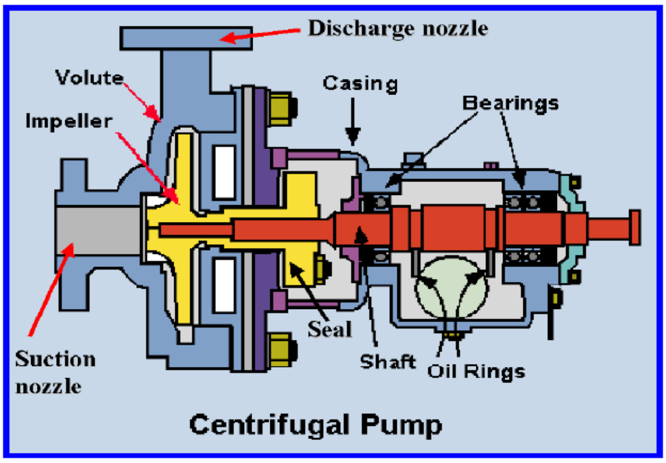
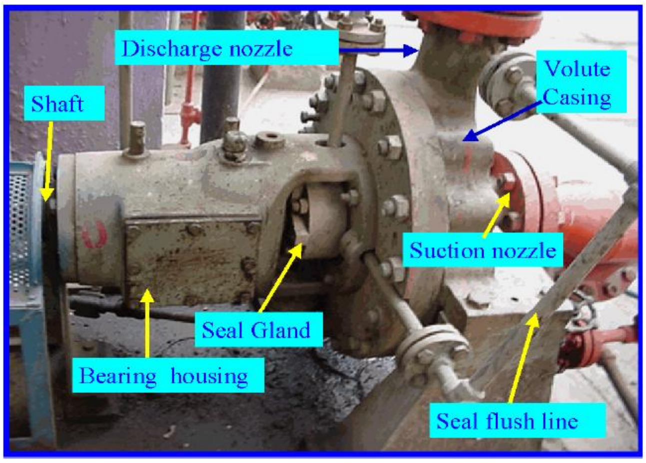
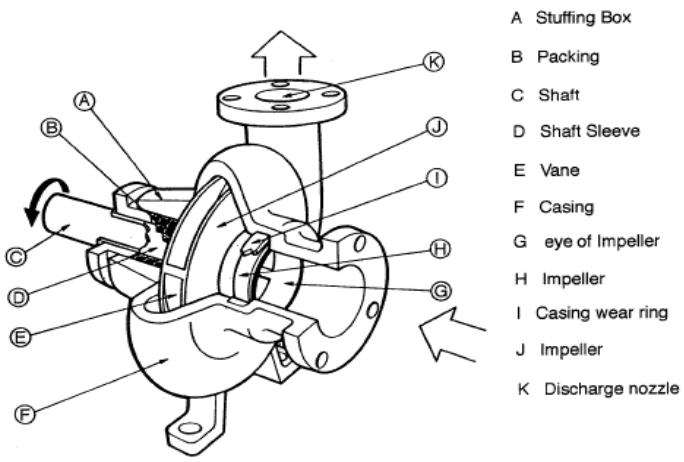
Centrifugal Pump Gener al Components





Parts of the centrifugal Pump

- Pump casing (Vent to remove gases)
- Pump shaft
- Volute
- Diffuser
- Impeller
- Stuffing box
- Lantern Ring
- Impeller wearing ring
- Pump casing wearing ring



The Function of Pump Components

Impeller
An impeller is the part which imparts energy to the liquid being pumped. Energy is added to the liquid as it moves through the rotating vanes of the impeller .

Shaft
The impeller is firmly attached to the shaft and rotates with it. The shaft performs two jobs:

- Carry the impeller (s) and all other rotating parts and keep them in their correct position with respect to the pump casing.
- Transmit the required driving power to rotate the impeller (s)

Shaft Sleeve

- To protect the shaft from wear in stuffing box area.
- As spacer between different impellers in multi-stage pump.

Coupling
Transmits the required power to drive the pump shaft and all other rotating parts.

Wear Rings
One wear ring is fixed to the impeller and rotate with it (impeller wear ring). One wear ring is fixed to the pump casing and does not rotates (case wear ring).
These two wear rings together work to minimize the internal leakage inside the pump.

Pump Casing
It contains all rotating parts (shaft, impeller, impeller wear ring) etc.
Pump casing directs the liquid which leaves the impeller to the discharge nozzle (pump discharge).

Stuffing Box
It is a cylindrical cavity where the shaft passes into the casing. The packing material presses around the shaft in this cylindrical cavity to minimize the leakage of liquid to outside the pump. A mechanical seal may be used instead of packing.

Bearings
function is to carry the pump rotor and keep it in its correct position with respect to the casing.

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Impoetant Defentions

- **Pressure -** Measured in pounds per square inch (PSI). The force exerted by the liquid.
- **Flow -** The measure of the liquid volume capacity of the pump. Gallons per hour (GPH) or (GPM).
- **Static Discharge Head - Vertical** distance (in feet) from pump to point of discharge.
- **Flooded Suction** - Liquid flows to the pump by gravity when liquid source is higher than pump. Preferable for centrifugal pump installation.
- **Prime -** When liquid source is lower than the pump, a charge of liquid is required to begin pumping action of centrifugal pumps. The liquid may be held in the pump by a foot valve on the intake line or a valve or chamber within the pump.
- **Seal, Mechanical -** A device mounted in the pump housing and/or on the pump shaft to prevent leakage of liquid from the pump. Has a rotating part and a stationary part with highly polished touching surfaces. Has excellent sealing capability and life, but can be damaged by dirt or grit in the liquid.
- **Viscosity -** The "thickness" of a liquid, or its ability to flow. Temperature must be stated when specifying viscosity, since most liquids flows more easily as they get warmer. The more viscous the fluid, the slower the pump speed required.
- **Dynamic Suction Lift -** Vertical distance from source of supply when pumping at required capacity, to centerline of pump, plus velocity head, entrance and friction loss, but not including internal pump losses, where static suction head exists but where the losses exceed the static suction head. The dynamic suction lift is the sum of the velocity head, entrance, friction, minus the static suction head, but not including internal pump losses.
- **Head - I**ndicates the height of a column of water being pushed by the pump. Expressed in feet or meters. For water, divide head in feet by 2.31 to get pressure in pounds per square inch.
- **Suction Head -** Sometimes called head of suction, exists when the pressure measured at the suction nozzle and corrected to the centerline of the pump is above atmospheric pressure.
- **Static Suction Head -** Vertical distance from the free level of the source of supply to centerline of pump.
- **Total Suction Head (HS):** The suction reservoir pressure head (hpS) plus the static suction head (hS) plus the velocity head at the pump suction flange (hVS) minus the friction head in the suction line (hfS).

$$H_S = hp_S + h_S + h_{vS} - h_{fS}$$

The total suction head is the reading of the gauge on the suction flange, converted to feet of liquid.

- **Static Discharge Head (hd):** It is the vertical distance in feet between the pump centerline and the point of free discharge or the surface of the liquid in the discharge tank
- **Total Discharge Head (Hd):** The discharge reservoir pressure head (hpd) plus static discharge head (hd) plus the velocity head at the pump discharge flange (hvd) plus the total friction head in the discharge line (hfd).

$$H_d = hp_d + h_d + hv_d + hf_d$$

- **Total Differential Head (HT): It** is the total discharge head minus the total suction head or

$$HT = Hd + HS \text{ (with a suction lift)}$$

$$H_T = H_d - H_S \text{ (with a suction head)}$$

- **Dynamic Suction Head -** The reading of a gauge connected to suction nozzle of pump, minus vertical distance from center of gauge to centerline of pump, as determined on test. Suction head, after deducting the various losses, may be negative quantity, in which case a condition equivalent to suction lift will prevail.

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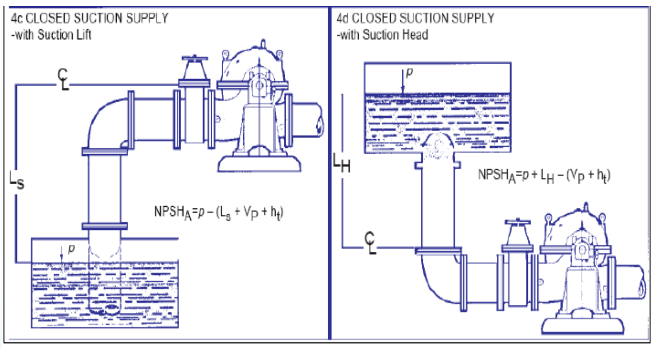
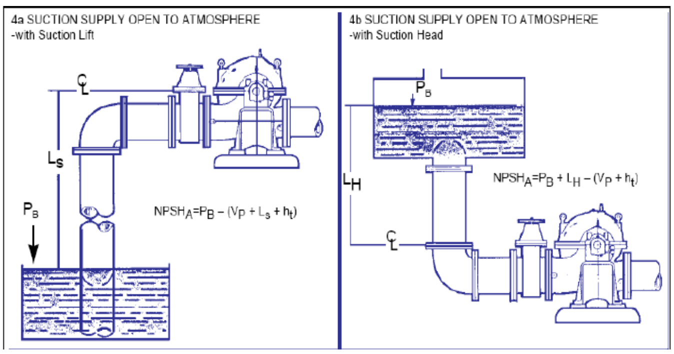
- **Friction Head (hf):** The head required to overcome the resistance to flow in the pipe and fittings. It is dependent upon the size, condition and type of pipe, number and type of pipefittings, flow rate, and nature of the liquid.
- **Vapor Pressure Head (hvp):** Vapor pressure is the pressure at which a liquid and its vapor co-exist in equilibrium at a given temperature. The vapor pressure of liquid can be obtained from vapor pressure tables.
- **Pressure Head (hp):** Pressure Head must be considered when a pumping system either begins or terminates in a tank which is under some pressure other than atmospheric. The pressure in such a tank must first be converted to feet of liquid.
- **Velocity Head -** Sometimes called head due to velocity, the velocity head of water moving with a given velocity is the equivalent head through which it would have to fall to acquire the same velocity; or the head necessary merely to accelerate the water. Knowing the velocity, we can readily figure the velocity head from
- **Total Head -** The sum of friction loss, discharge head and suction lift.
- **Static Head -** The vertical distance between the free level of the source of supply and the point of free discharge, or the level of the free surface of the discharged liquid.
- **Total Dynamic Head -** The vertical distance between source of supply and point of discharge when pumping at required capacity, plus velocity head, friction, entrance and exit losses**.**
- **Lift (Suction Lift) -** Liquid is lower than the pump. Pumping action creates a vacuum and atmosphere pressure forces liquid up to pump. Theoretical limit of suction is 34 feet; practical limit is 25 feet or less, depending on pump types and elevation above sea level**.**
- **Static Suction Lift -** Vertical distance from the free level of the source of supply to centerline of pump.
- **net positive suction head NPSH,** total absolute suction pressure determined at the suction nozzle and referred to the datum elevation, minus the pressure of the liquid, in units of metres (feet) of head of the pumped liquid
- **net positive suction head available NPSHA,** NPSH determined by the purchaser for the pumping system with the liquid at the rated flow and normal pumping temperature
- **net positive suction head required NPSHR,** NPSH that results in a 3% loss of head (first stage head in a multistage pump) determined by the vendor by testing with water
- **nominal pipe size NPS,** designation, usually followed by a size designation number, corresponding approximately to the outside diameter of the pipe, expressed in inches
- **normal operating point,** point at which the pump is expected to operate under normal process conditions

Notes :





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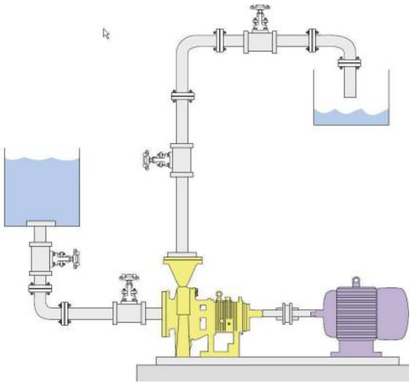
Important Equations

$$NPSHa_S = hp_S + h_S - hvp_S - hf_S$$

- hp_S - Pressure Head i.e Barometric Pressure of the suction vessel converted to Head
- h_S - Static suction Head i.e.the vertical distance between the eye of the first stage impeller centerline and the suction liquid level.
- hvp_S - Vapor pressure Head i.e. vapor pressure of liquid at its max. pumping temperature converted to Head
- hf_S - Friction Head i.e. friction and entrance pressure losses on the suction side converted to Head



Converts Kinetic Energy to Pressure Energy

$$v = \frac{N \times D}{229}$$

where

- **v = Velocity at periphery of impeller in ft/sec.**
- **N = The impeller RPM (revolutions per minute)**
- **D = Impeller diameter in inches**

$$H = \frac{v^2}{2g}$$

where

- **H = Total head developed in feet.**
- **v = Velocity at periphery of impeller in ft/sec.**
- **g = Acceleration due to gravity - 32.2 feet/Sec^2**

Power and Efficiency

- **Brake Horse Power (BHP)** The work performed by a pump is a function of the total head and the weight of the liquid pumped in a given time period.
- **Pump input or brake horsepower (BHP**) is the actual horsepower delivered to the pump shaft .
- **Pump output or hydraulic or water horsepower (WHP)** is the liquid horsepower delivered by the pump. These two terms are defined by the following **formulas.**

$$BHP = \frac{Q \times H_T \times Sp.Gr.}{3960 \times Eff.}$$

where

- **Q = Capacity in gallons per minute (GPM).**
- **H_T = Total Differential Head ,ft**
- **$Sp.Gr.$ = Specific Gravity of the liquid**
- **$Eff.$ = Pump efficiency , %**

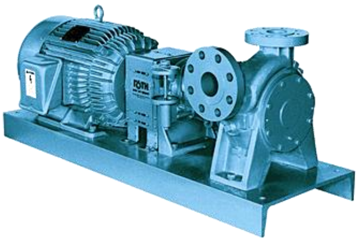
$$WHP = \frac{Q \times H_T \times Sp.Gr.}{3960}$$

where

- **Q = Capacity in gallons per minute (GPM).**
- **H_T = Total Differential Head ,ft**
- **$Sp.Gr.$ = Specific Gravity of the liquid**

Therefore the pump efficiency is the ratio of these two values.

$$\text{Pump Efficiency } (Eff.) = \frac{WHP}{BHP}$$



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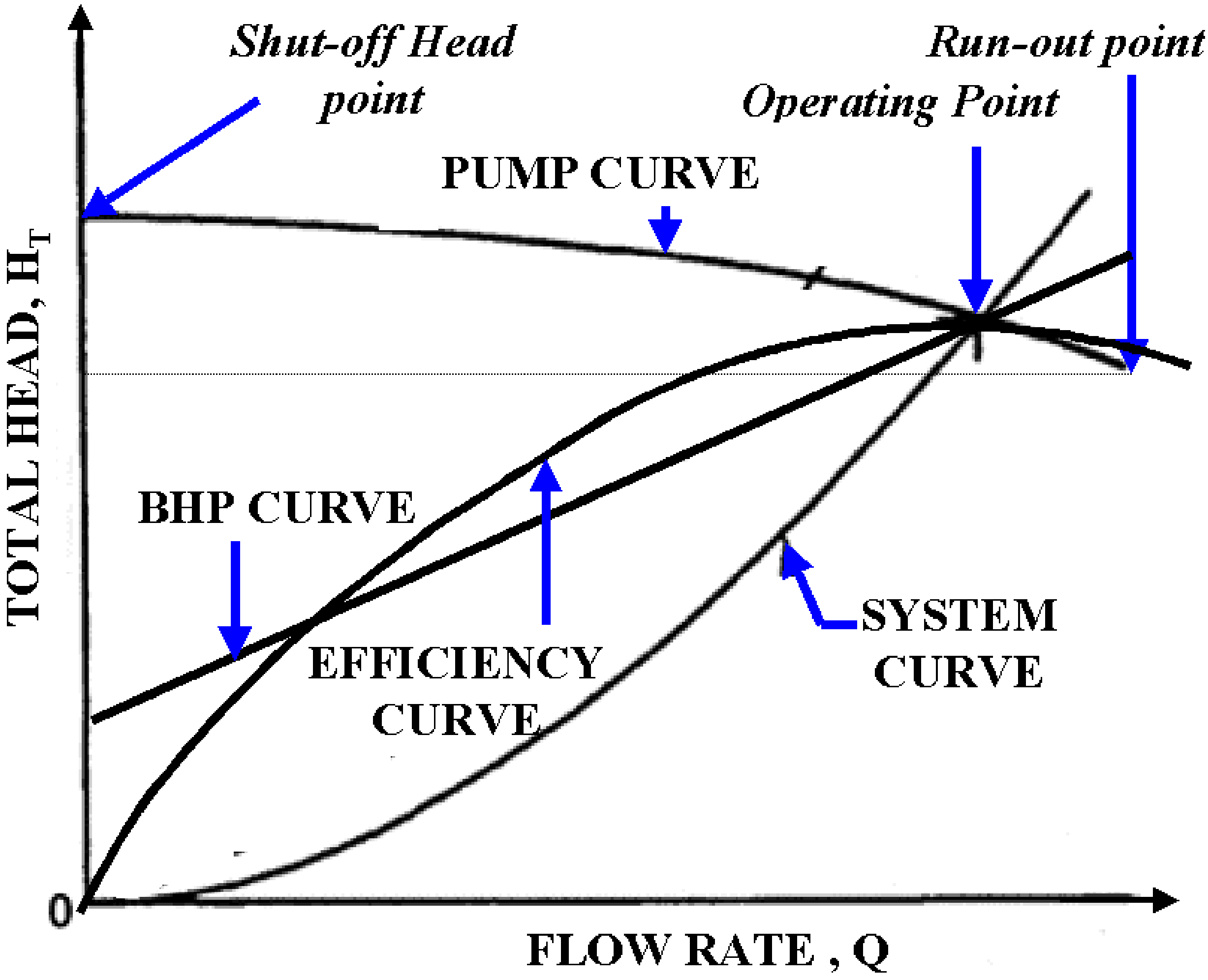
Understanding Centrifugal Pump Performance Curves

- **The capacity and pressure needs of any system can be defined with the help of a graph called a *system curve*. Similarly the capacity vs. pressure variation graph for a particular pump defines its *characteristic pump performance curve*.**
- **The pump suppliers try to match the system curve supplied by the user with a pump curve that satisfies these needs as closely as possible. A pumping system operates where the pump curve and the system resistance curve intersect. The intersection of the two curves defines the operating point of both pump and process. However, it is impossible for one operating point to meet all desired operating conditions. For example, when the discharge valve is throttled, the system resistance curve shift left and so does the operating point.**



In a nutshell, by plotting the system head curve and pump curve together, you can determine:

1. Where the pump will operate on its curve?
2. What changes will occur if the system head curve or the pump performance curve changes?

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Cavitation Problem

When a liquid enters a pump, its velocity increases causing a reduction in pressure within the pumping unit. If this pressure falls too low, some of liquid will vaporize, forming bubbles entrained in the liquid. These bubbles collapse violently as they move to areas of higher pressure. The formation and sudden collapse of these bubbles is called Cavitation.

Cavitation - Two Main Causes:

A. NPSH (r) Exceeds NPSH (a)

- Due to low pressure the water vaporizes (boils) and higher pressure implodes into the vapor bubbles as they pass through the pump causing reduced performance and potentially major damage.

B. Suction or discharge recirculation

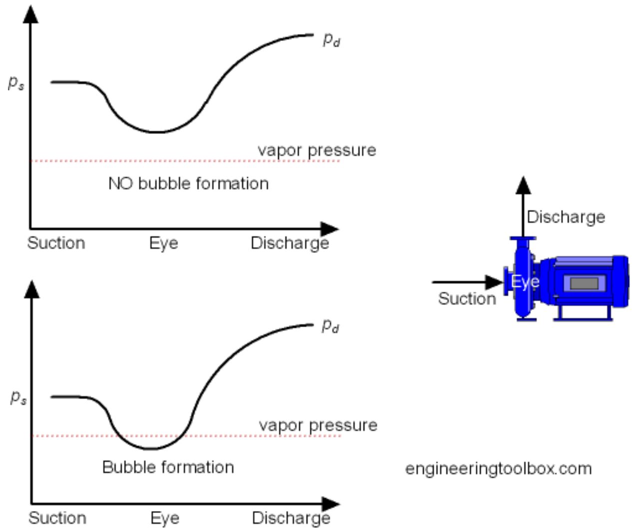
- The pump is designed for a certain flow range, if there is not enough or too much flow going through the pump, the resulting turbulence and vortexes can reduce performance and damage the pump.

What Damage Does Discharge Cavitation Cause?

- Break Shafts
- Shortens Bearing Life
- Destroys Impellers and Volutes
- Ruins Mechanical Seals

What Damage Does Suction Cavitation Cause?

- Shortens Bearing Life
  (Increased radial & thrust loads)
- Destroys Impellers
- Destroys Wear Plates
- Ruins Mechanical Seals
  (Vibration & thrust loads)



To avoid cavitation, NPSHA must always be greater than NPSHR at the design flow.

How to avoid cavitation?

- minimize the number of valves and bends in the suction line
- use eccentric reducers, not concentric
- ensure the straight side of the eccentric reducer is installed along the top of the suction line
- Suction length should be as short as possible
- Suction pipe should be at least the same diameter as the p
- use long radius bends
- increase the size of valves and pipe work
- do not allow air into the suction line

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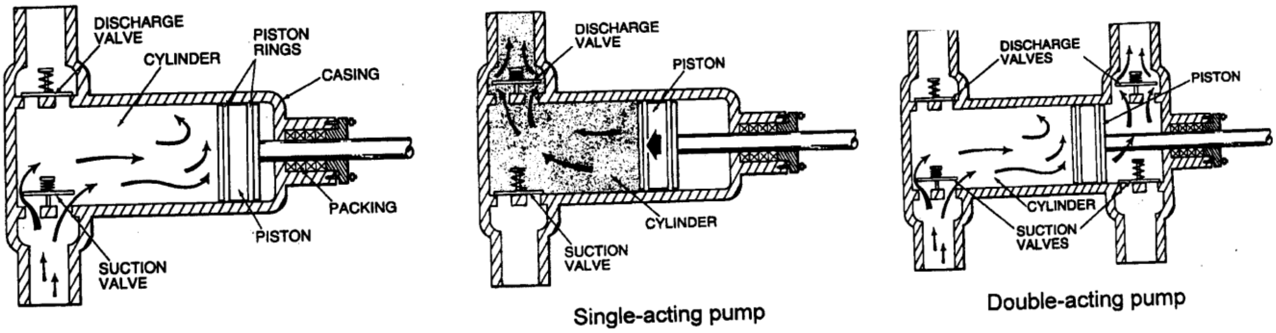
Positive displacement

Positive pumps have the following advantages over negative displacement pumps:-

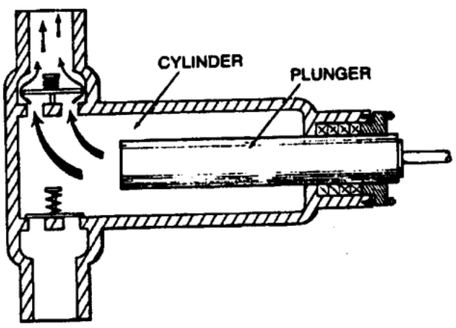
- High-pressure capability up to 680 bar (10,000 psi) or higher.
- Small and compact size.
- High volumetric efficiency.
- Small changes in efficiency throughout the design pressure range.
- Great flexibility of performance (can operate over a wide range of pressure requirements and speed ranges).

Reciprocating pump.

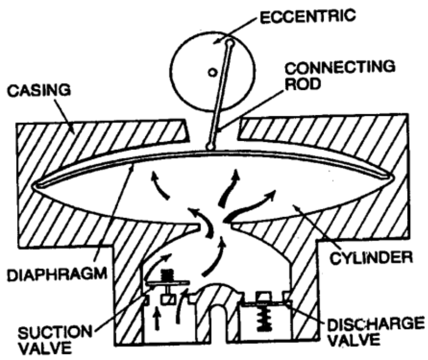
- In this type of pump action is produced by the (reciprocating) movement of piston or plunger with in a cylinder.
- The liquid is being pumped is drawn into the cylinder through one or more suction valves and then forced out through one or more discharge valves by direct contact with the piston or plunger



Reciprocating Piston Pump



Plunger pump



Diaphragm pump

principle of operation

- Liquid enters the cylinder through suction valves on the back stroke and is displaced through discharge valves on the forward stroke.
- The cylinder valves act like check valves, permitting flow only in one direiction. Pressure diffirance control the action of the valves.

Rotary Positive Displacement Pumps

- **Single rotor**
  Screw pumps, sliding vane pumps, etc.
- **Multiple rotor**
  Gear pumps lobe pumps and screw pumps.

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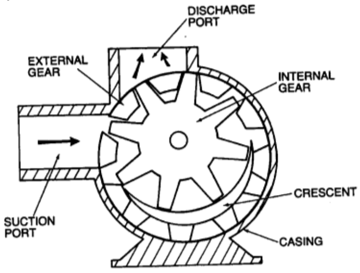
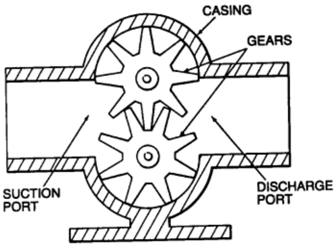
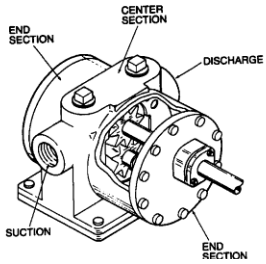
Rotary pump (Gear Pump)

- Gear pumps belong to a positive displacement rotary group, and are made by enclosing two or more gears in a close-fitting housing. A driver turns a shaft connected to one of the gears, causing it to rotate This gear drives the other gear through the meshing of the teeth of the two gears
- 1)-External
  2)- Internal

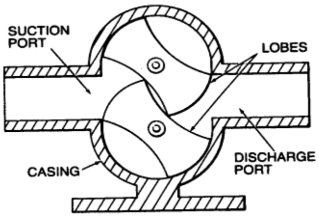


Internal gear pump

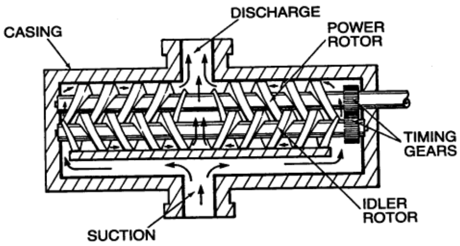




External gear pump



Lobe pump



Screw pump

Troubleshooting

1. Pump Will Not Start

1.1 Blown fuses or tripped circuit breakers due to:

A. Rating of fuses or circuit breakers not correct
B. Switch (breakers) contacts corroded or shorted
C. Terminal connections loose or broken somewhere in the circuit
D. Automatic control mechanism not functioning properly

2. Reduced Rate Of Discharge

1. Pump not primed
2. Mixture of air in the wastewater
3. Speed of motor too low
4. Discharge head too high
5. Discharge line clogged
6. Check vales stuck or clogged

3. High Power Requirements

1. Speed of rotation too high
4. Specific gravity or viscosity of liquid being pumped too high
7. Pump shaft bent

4. Noisy Pump

1. Pump not completely primed
2. Pump not lubricated properly Or Mechanical defects in pump
3. Misalignment of motor and pumps where connected by flexible shaft

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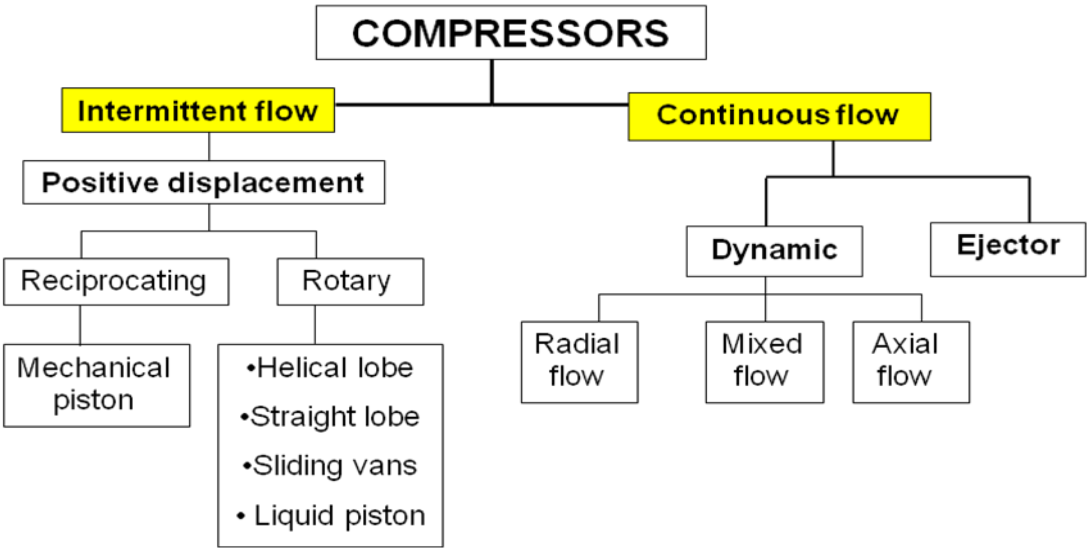
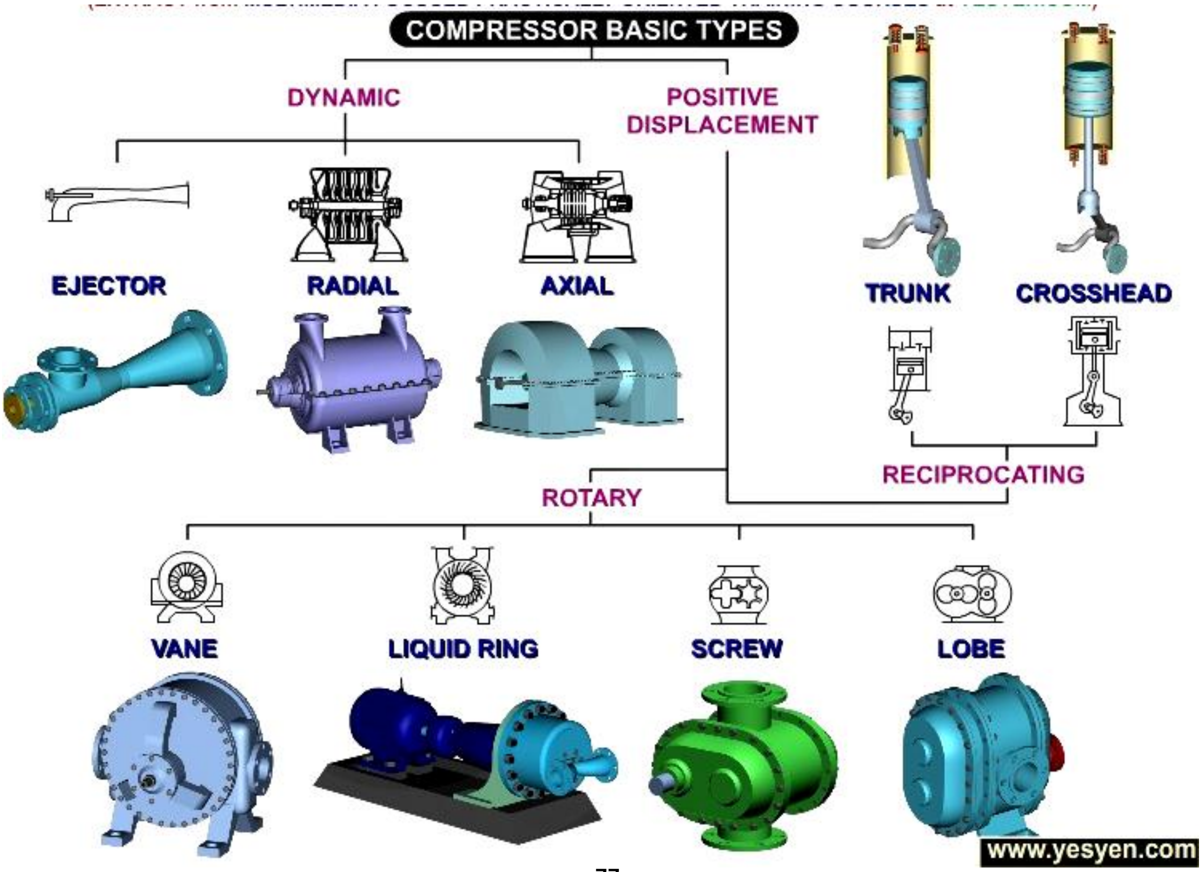
B- Compressors:

A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Compressors are prime movers of gas and air in process industries. They are used to increase static pressure of the gas and deliver it at specified pressure and flow rate in a process application.

Use of compressed gas can be found in numerous applications. The simplest being use of compressed air for various purpose to critical compressed gas requirements in Process industries. Compressors are similar to pumps, both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of gas. Liquids are relatively incompressible, so the main action of a pump is to transport liquids





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Reciprocating compressors uses pistons to "push" gas to a higher pressure. These are Positive Displacement machines. It first traps a volume of gas or vapor in a casing and then the gas is displaced in a smaller volume or space, the greater the reduction in volume, the greater the increase in pressure. A compressor, which operates by volumetric displacement, is called a positive displacement compressor. They are common in natural gas gathering and transmission systems, but less common in process applications. Reciprocating compressors can produce very large pressure differences, but because they produce a pulsating flow, may require a receiver vessel (discharge snubber) large enough to dampen the pulsation. Reciprocating compressors are furnished in either single or multistage types. The number of stages depends on the inlet and the required outlet pressure (compression ratio).

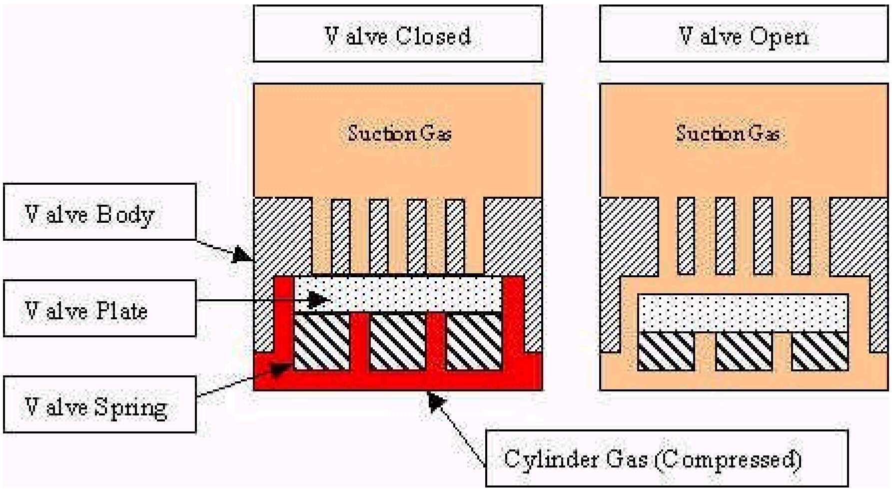
Dynamic compressors use rotating blades to add velocity and pressure (centrifugal tendency) to a fluid stream. They operate at high speeds and are driven by steam or gas turbines or electric motors. Dynamic compressors tend to be smaller and lighter (and hence less expensive) than reciprocating machines in the same service. Gas enters a centrifugal or axial compressor through a suction nozzle and is directed onto the first-stage impeller by a set of guide vanes. The blades push the gas forward and into a diffuser section where gas velocity is slowed and kinetic energy transferred from the blades is converted into pressure.

Reciprocating Compressor

How Reciprocating Compressor Works:

Valve Closed: The piston is moving towards the valve (compressing) in this instance.
Compressed gas in the cylinder (in red) is at a higher pressure than the suction gas. The compressed gas pushes the valve plate toward the valve body (or seat) assisted by the springs. The plate seals and holds the suction gas back allowing the compression cycle to complete

Valve Open: The piston is moving away from the valve (de-compressing) in this instance.
After the piston reaches the end of its' stroke and begins to move in the opposite direction, the compressed gas looses its pressure. The cylinder pressure becomes lower



than the Suction Gas pressure and drops to the point that the Suction Gas pressure overcomes the valve spring tension. This allows the valve plate to move down and Suction Gas to enter the cylinder through the valve passages and into the cylinder for compression.

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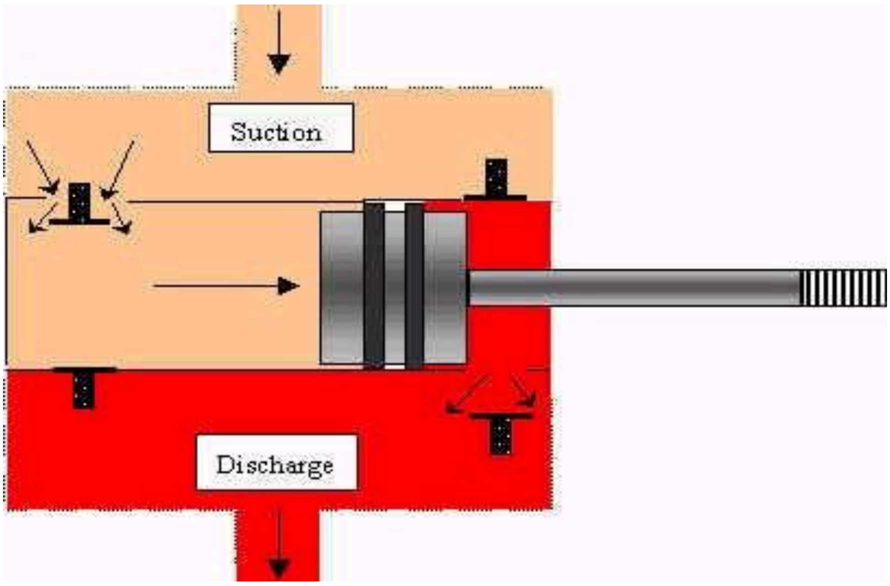
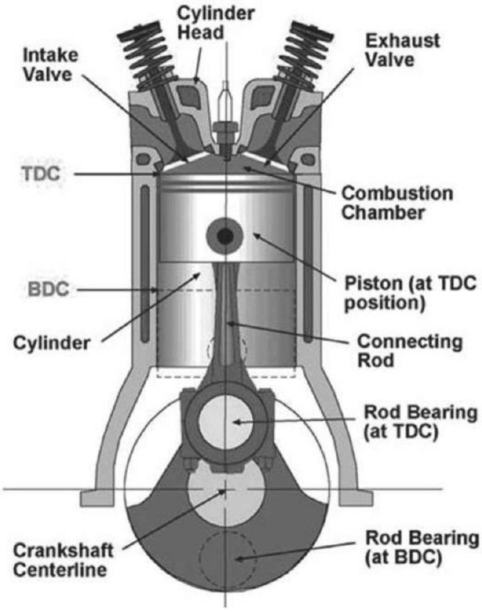
The discharge valve works the same way and in opposite sequence with the suction valve. In other words when the suction valve opens, the discharge valve (on the same end) is closed. The following illustration shows a single stroke of the piston and the valve action that takes place.

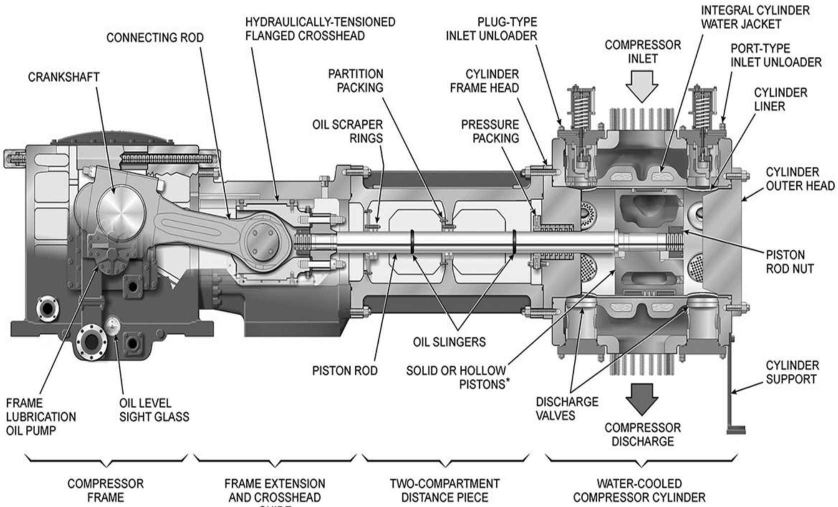


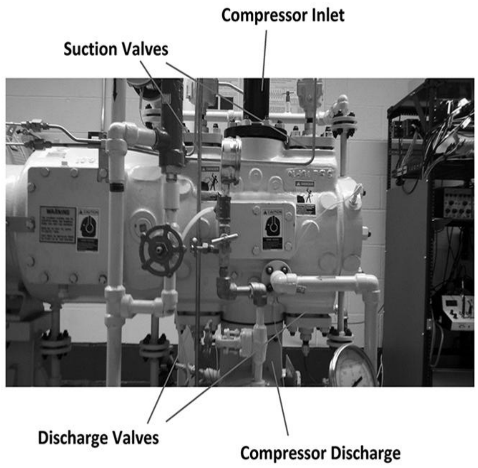
As the piston reverses direction the same action takes place on the other end.

<u>Main Parts of Reciprocating Compressors</u>

- Compression Unit
- Driver Unit
- Crankshaft
- Crosshead
- Connecting Rod
- Piston Rod
- Piston
- Cylinder
- Suction Valves
- Discharge Valv es
- Suction Port
- Discharge Port
- Cooling System
- Lubrication System







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BASIC TERMINOLOGIES

Compressor Cycle:

Simply spoken, a compressor takes gas at one (lower) pressure and increases it to another (higher) pressure. The amount of increase depends on the size of the cylinder and length of stroke of the piston. The compression cycle in a positive displacement compressor can be thought of in a single stroke of the piston. As the piston moves, leaving a larger area behind it, gas enters the space that the piston occupied. The gas enters through a valve (or series of valves). The valves only open one way and in effect are check valves. Valves open and close by pressure differential and spring action.

Compression Ratio:

The compression ratio is a key parameter in evaluating compressors. The compression ratio is defined as

$$\mathbf{R = P_{out} / P_{in}}$$

The compression ratio per stage is generally limited to 4. Higher ratios can be achieved using multiple compression stages.

Revolution:

In a reciprocating compressor, one forward stroke and one backstroke is called one revolution. If gas is discharged on only the backstroke the compressor is said to be a single acting. In a single acting compressor the forward stroke is the compression stroke while the backstroke is the suction stroke where as in a double acting compressor gas is compressed on both sides of the piston thus the double acting compressor has two discharge strokes per revolution.

Clearance Volume

The volume of gas, which is left inside the cylinder at discharge pressure, is called clearance volume

Horse Power:

HP required by the compressor depends on the work done in a given time and on the compressor mechanical efficiency.

Brake Horse Power:

Brake horsepower, the effective or available power have an engine or turbine, measured at the output shaft. It is equivalent to the calculated horsepower, less the power lost in friction.

Capacity:

The capacity of a compressor is the volume of gas trapped in a cylinder per unit time. Total capacity of recycle gas compressor.

Mechanical Efficiency:

Mechanical Efficiency is the ratio of the horsepower applied to the gas to the horsepower received from the driver or prime mover.

$$\acute{\eta}_m = HP_a / HP_r$$

Volumetric Efficiency:

The ratio of the actual capacity of the compressor to the volume of the gas that it should theoretically handle.

$$\acute{\eta}_v = C_a / C_t$$

Throttling:

Some times it is necessary to change the capacity or the rate of flow through the compressor. Suction line throttling can do this. **Throttling** is partially closing or pinching the valve in the compressor suction line.

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Reciprocating Compressor Troubleshooting

- Noisy Valves
- Hammering Piston
- High Gas Discharge Temperature
- High Suction Pressure
- Low Suction Pressure
- Hot Suction
- Hot Packing
- Low Jacket Water Level
- High Jacket Water Temperature

Centrifugal Compressor

In dynamic compressors energy is transferred from a moving set of blades to the gas. The energy takes the form of velocity and pressure in the rotating element, with further pressure conversion taking place in the stationary elements. Because of the dynamic nature of these compressors, the density and molecular weight have an influence on the amount of pressure the compressor can generate.

Operation:

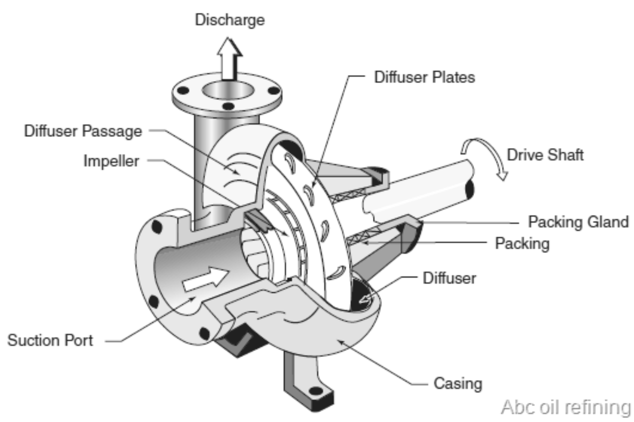
1. Gas/vapor enters the compressor at the suction inlet.
2. The impeller accelerate the gas.
3. The impeller discharges the gas to a diffuser.
4. The diffuser is a circular, narrow chamber.
5. A back pressure is created in the impeller due to the acceleration.
6. The gas velocity increases in the diffuser.
7. As the gas speed slows in the volute , the kinetic energy is converted into pressure.
8. The compressed gas exits at the discharge line

Advantages of centrifugal compressors:

9. Low initial instillation.
10. Large volume capacity / unit plot area.
11. Interchangeable derivers.
12. Delivers much higher flow rates than the positive displacement.
13. Long service life

Main Parts of Centrifugal Compressors

1. Bearing and Seals
2. Horizontal Split Casing
3. Vertical Split Casing
4. Rotors
5. Impellers
6. Balancing Piston
7. Diaphrams
8. Lubricating Oil System
9. Gear & Coupling
10. Suction & Discharge Valves



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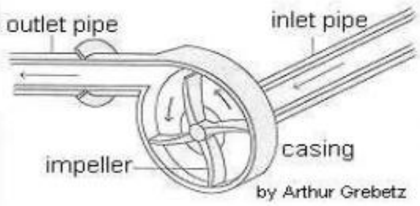
Dynamic Compressors Types

* Radial-Flow - Also called Centrifugal.
- Radial flow path.
- Large change in radius from inlet to outlet.

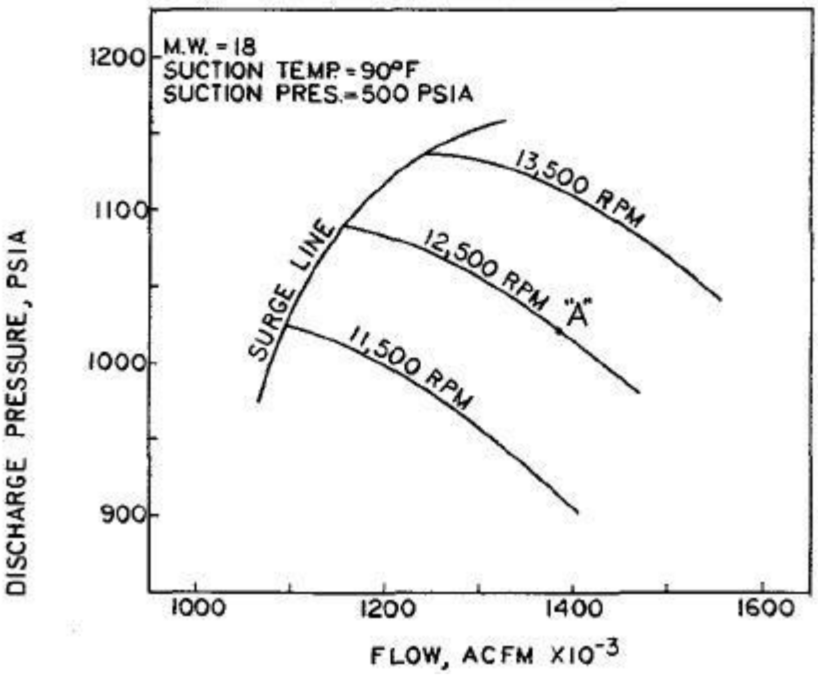


* Axial-Flow - Flow path nearly parallel to the axis of rotation.
- Radius of the flow path does not very significantly.

* Mixed-Flow - Flow path radius changes only moderately.

SURGE

The Standard operating curve of a dynamic compressor will look like



It means, maximum discharge pressure is obtained at minimum flow and vice versa for a particular speed. Now surge is the operating point, where **Maximum head and minimum flow capacity is reached.** Now principle of working of a compressor is -*Imparting Kinetic Energy to the fluid in impeller and conversion of this energy into pressure energy by decreasing speed in Diffuser*. So, if maximum head capacity is reached, then pressure in diffuser will be greater than pressure at impeller outlet. This will prevent fluid from moving further at impeller outlet and causes the fluid in diffuser to flow back, i.e. flow reversal takes place. This can be deteriorating as it has potential to damage the bearings and other rotating parts, and also cause high vibrations. This can be rectified by providing an anti surge valve, which takes fluid from discharge and directs it to suction so that flow is increased and surge is controlled.

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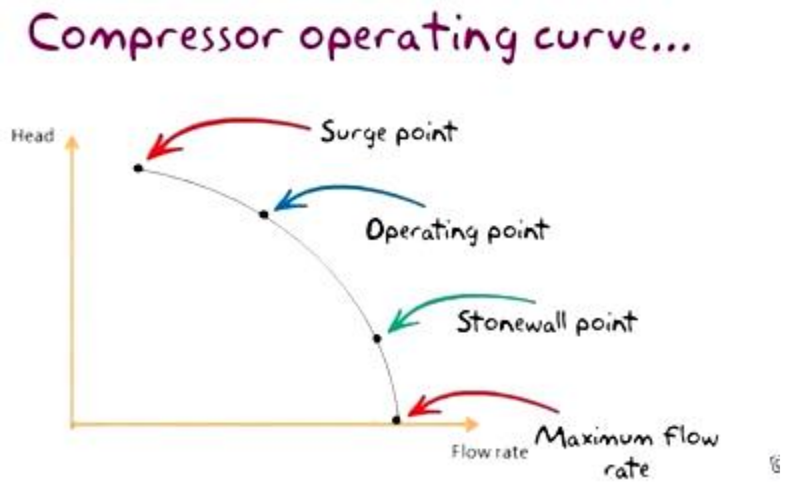
In above graph, the line joining minimum flow points for each speed is called Surge Line, and compressor must operate to the right side of it.

CHOKING

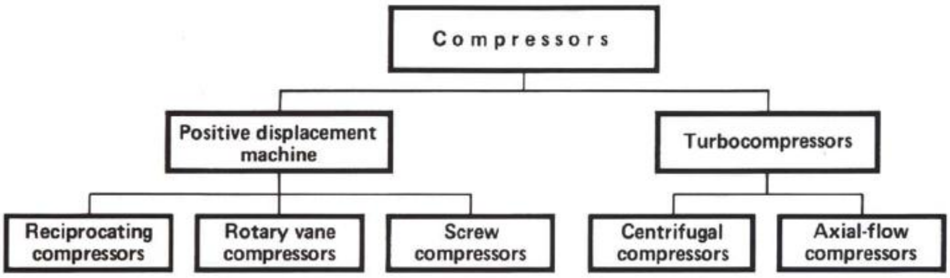
Consider the following operating curve:



Compressor operates, somewhere between Surge point and Stonewall Point also known as Choking Point. We know what'll happen if flow is decreased, and pressure increases. Its called surge. Now, if flow increases, and discharge pressure decreases, then it means that back pressure experienced by the fluid will be less, i.e. resistance to flow is decreased. Hence, flow increases, and flow velocity increases up to maximum MACH1 i.e. sonic speed. This is very high speed and may cause severe damage to the compressor. This can be prevented by maintaining minimum flow resistance to the fluid flow by providing Anti-choke valves at discharge which closes to restrict the flow and hence preventing Choke.

So Compressor must operate in between Surge point and Choke/Stonewall Point.

Compressor Selection



Compression	Volume			Conversion of kinetic energy	
Motion	Reciprocating	Rotating		Rotating	
Delivery	Intermittent	Quasi-continuous		Continuous	
Volume flow	Low	Low	Low/medium	Low/high	Very high
Compression ration	High	Medium		Medium	Low
Operation	Constant volume – Variable pressure			Variable volume – Quasi-constant pressure	
Principle					
Function of a compressor	To render a specific volume of gas from a given initial condition into a desired final condition (pressure/temperature).				

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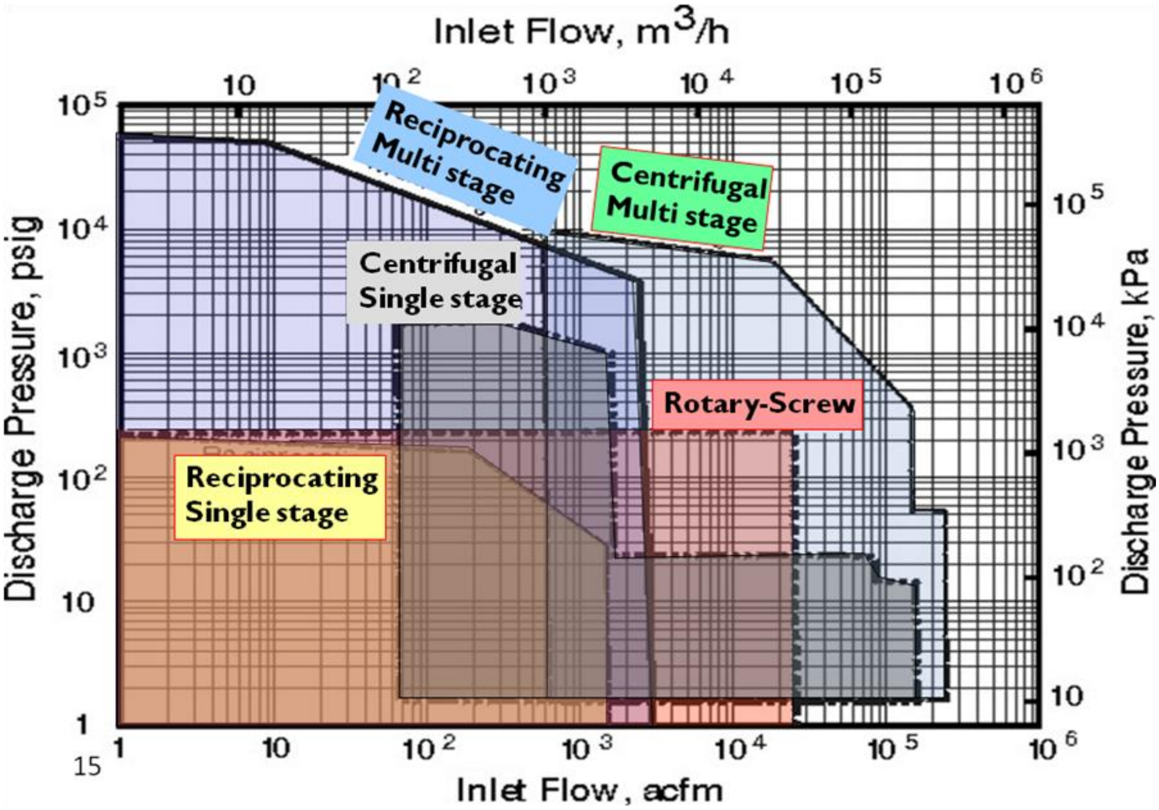

Comparison Between Compressors Types

Type	Advantages	Disadvantages
Centrifugal	- Wide operating range - Low maintenance - High reliability	- Unstable at low flow - Moderate efficiency
Axial	- High efficiency - High speed capability - Higher flow for a given size	- Low pressure ratio per stage - Narrow flow range - Fragile and expensive balding
Positive displacement	- Pressure ratio capability not affected by gas properties - Good efficiencies at low specific speed	- Limited capacity - High weight to capacity ratio - Higher maintenance requirements - Introduces vibrations into the system - Bigger foundation requirements

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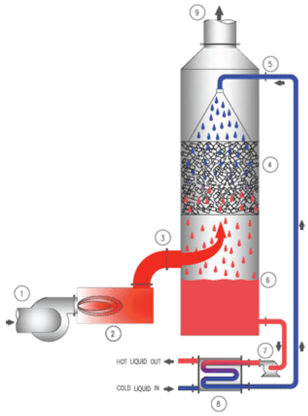
Heat Exchangers

Definition

A heat exchanger is a heat-transfer device that is used for tran sfer of internal thermal energy between two or more fluids available at different temperatures. In most heat exchangers, the fluids are separated by a heat-transfer surface, and ideally they do not mix.

Importance of heat transfer

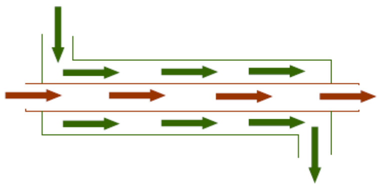
1-To control the rate of chemical reactions [exothermic and endothermic reactions]
2-A fluid temperature and/or its composition and phase;
3-To control mass transfer operations [distillation, evaporation……]
4-Power generation [steam boilers]



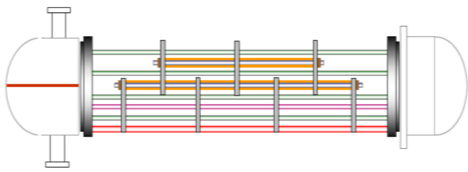
Types of Heat Exchangers

A - TRANSFER PROCESS
- Direct Contact
- Indirect Contact

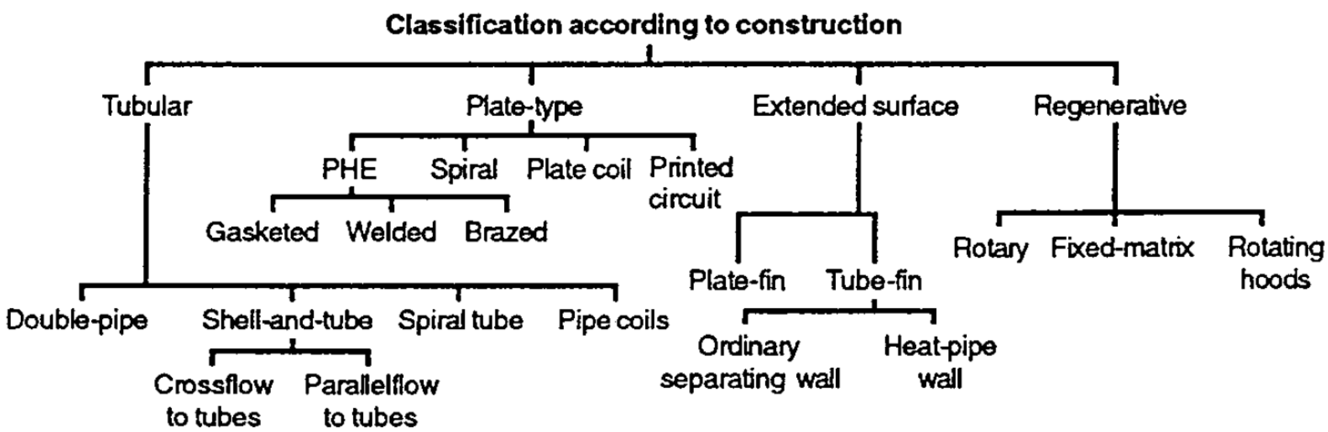
B - FLOW ARRANGEMENT
- Parallel Flow
- Counter Flow
- Cross Flow



C - GEOMETRY OF CONSTRUCTION
- Tubular
- Plate Type
- Extended Surface



Heat Exchangers Classification According To Construction



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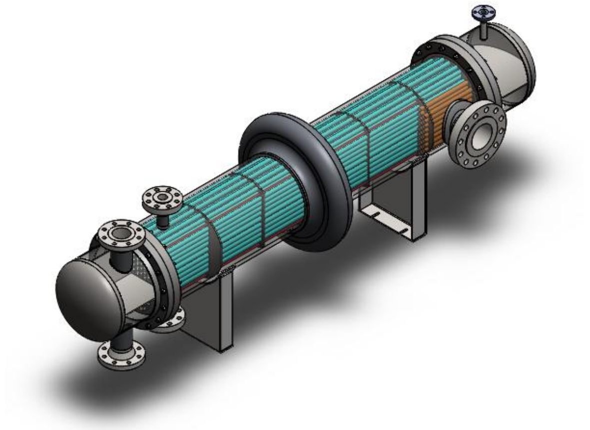
The principal Types of heat exchangers

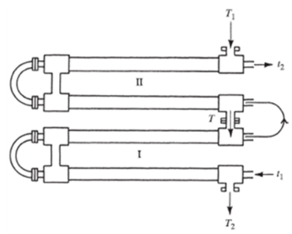


1. Double pipe heat exchangers
2. Shell and tube heat exchangers
3. Plate and frame heat exchangers
4. Plate fin heat exchangers
5. Spiral heat exchangers
6. Air cooled heat exchangers
7. Fired heaters [boilers]

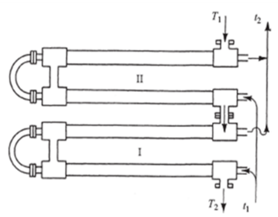
Double Pipe Exchangers

The inner pipe consists of a finned section and two lengths of finned pipe welded to a 180' return bond. The element or hair pin formed is then inserted into two shell pipes. The outside diameter of the fins is slightly less than the inside diameter of the shell. The shells are welded to an end plate, where the floating end of the hair pin is closed with a bolted and gasketed cover providing enough clearance for expansion and contraction of the inner tubes or elements.

Double pipe H.X in series

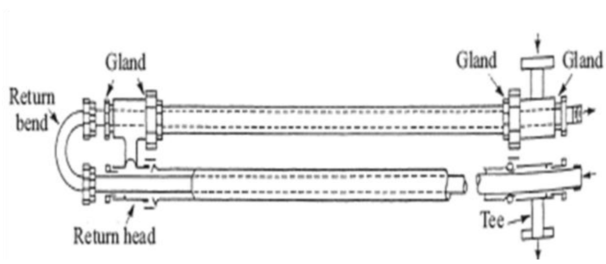


Double pipe H.X in parallel



1-Double pipe heat exchanger

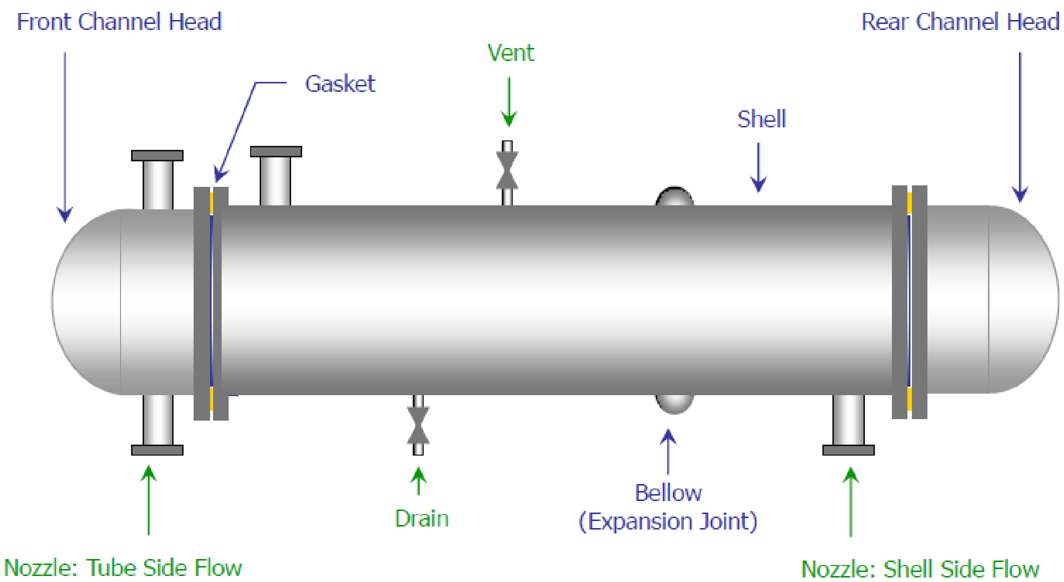
➢Construction



Shell & Tube Heat Exchangers

A shell and tube heat exchanger consists of a number of parallel tubes enclosed in a cylindrical shell.
One fluid flows inside the tubes and is called the tube side fluid. The other fluid flows outside the tubes and is called the shell side fluid. All shell and tube exchangers consist of basically the same parts, although they may be arranged differently to suit a specific need.

Basic Components -External Features



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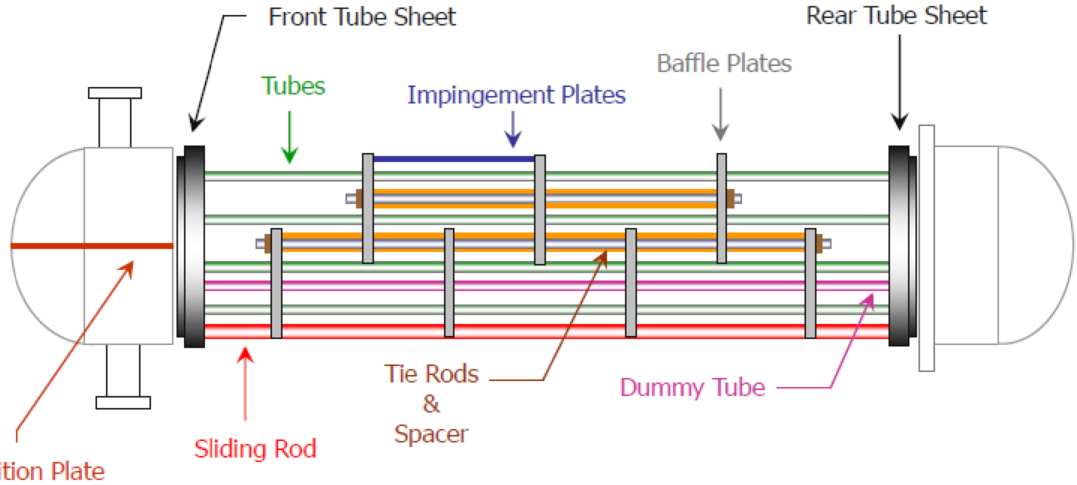
Basic Components -Internal Features



Shell and tube exchangers may be divided into the following classifications from the construction of the tube sheet. In all cases, the tubes are rolled or welded with the tube sheet to prevent leakage into the shell.

Types of shell and tube heat exchangers:

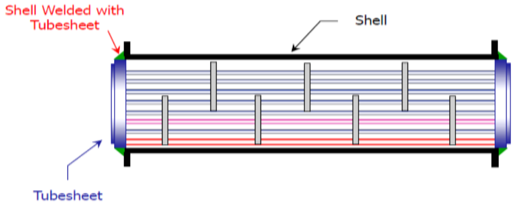
- Fixed tube sheet (plate)
- U- tube
- Internal floating head without clamp ring
- Internal floating head with clamp ring
- External floating head
- Kettle re-boiler with U- tube bundle

1. Fixed Tube Sheet

   This is the simplest form of exchanger, but has limitations:

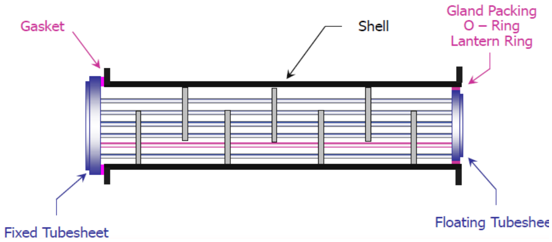
   a. Temperature limit of water cooler between the two fluids as there is no provision for expansion.

   b. Refiner cannot clean shell side. Limits the shell side fluid to a clean surface.



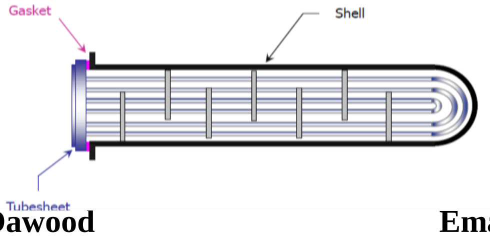
2. Floating Head

   To allow for tubes to expand due to the temperature difference in a heat exchanger, one tube sheet moves inside the shell. This floating head sheet must be enclosed by a floating head cover within the shell to return the tube side fluid to the channel end. Most heat exchangers are of this type.



3. U-Tube

   The tubes are one piece and made for a particular exchanger. The tubes can expand and contract and only one tube sheet is required. The bundle may be pulled for inspection, and cleaning the shell, but the tubes may only be cleaned with the use of chemicals. Most common use is in rebollers where steam is condensed in the tubes.



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4. Tube Bundles

Tube bundles consist of three main parts; tubes, tube sheets, and baffles. Tubes are necessary to keep the shell and tube side fluids separate. The tube sheet is for the same reason and the tubes are attached to the tube sheet. Baffles direct the flow of liquid through the shell side and support the tubes inside the shell. Tubes are spaced in the tube sheet in one of three patterns:

a. <u>Triangular Pattern</u>

This gives the most tubes for a given size but cleaning the outside of the tubes can only be done by chemical means.

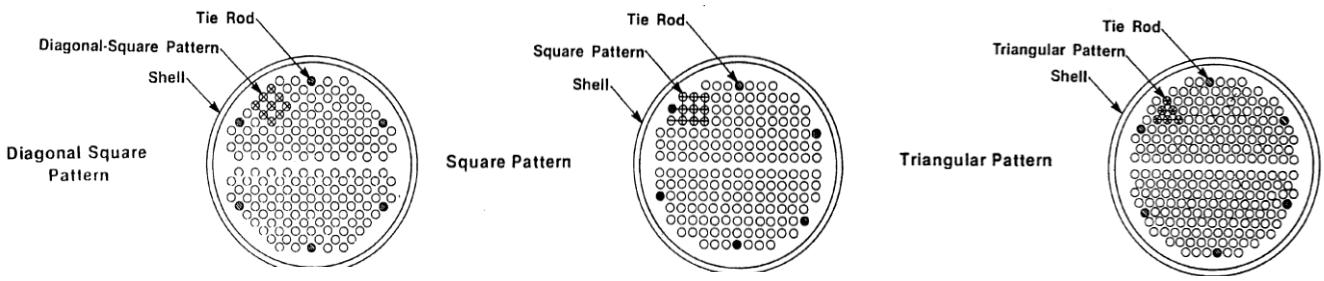
b. Square Pitch

This type is the easiest to clean the outside of the tubes.

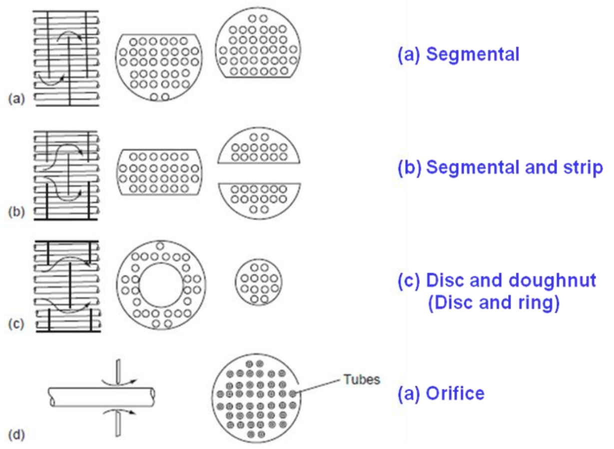
c. Diagonal Pitch

This is similar to square pitch but rotated through 45. This layout contains the least number of tubes.

Increasing the number of passes on the tube or shell side increases the velocity flow of the fluid which in turn increases the heat transfer rate.



Baffles



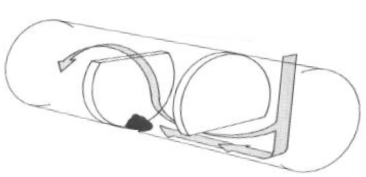
Salient Features

-Used to Support Tubes
-Creates Turbulence (Hence Enhanc e Heat Transfer)
-Increases Stay Time of Fluid

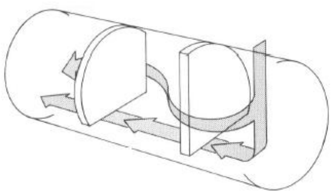
Disadvantages

-Increases Pressure Drop
-Creates Stagnant Point for Mud/Dirt
-Creates Operational Problem

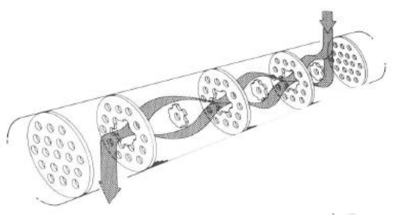
Baffles Types



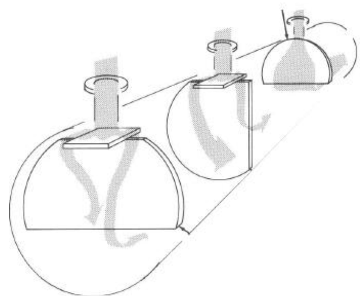
Horizontal Segmental Baffles



Vertical Segmental Baffles



Disk & Donut Baffles



Impingement Baffles

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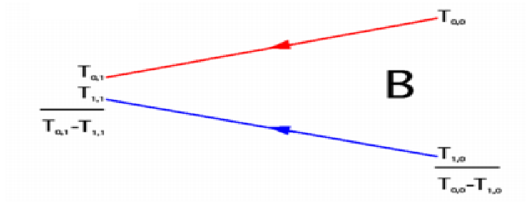
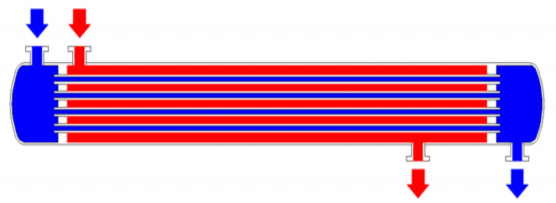
Direction through the heat exchanger:

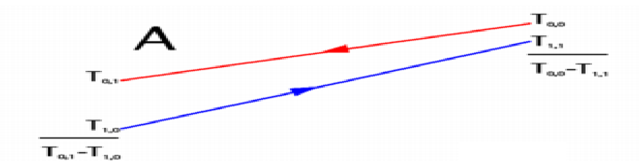
The three categories are parallel flow, counter flow and cross flow.

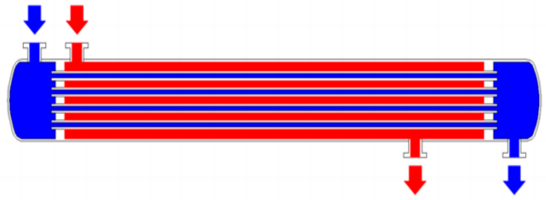
Parallel flow (co-current flow):



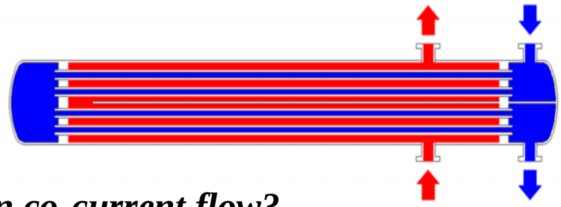


Counter Current flow





Cross flow



Why is counter current flow more efficient than co-current flow?

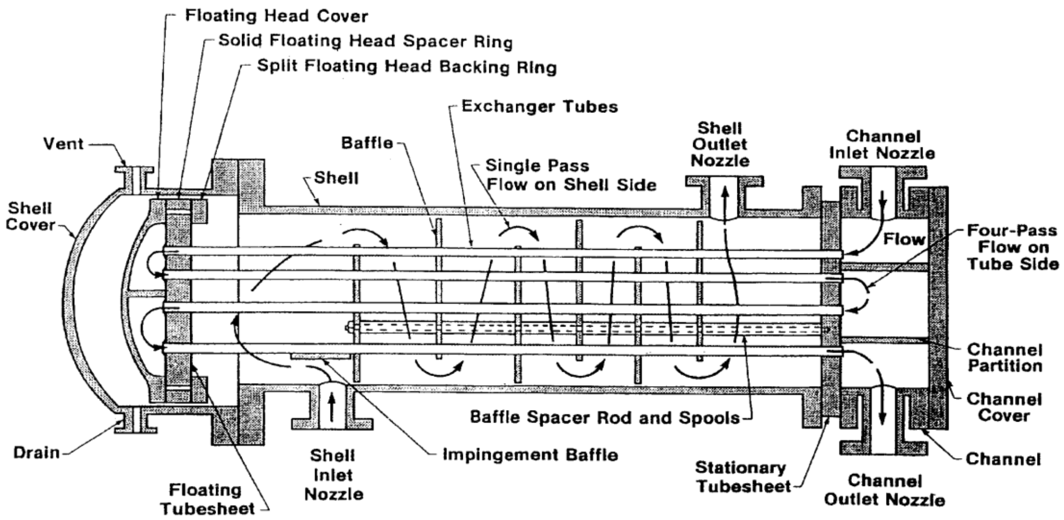
Because counter current flow can have the hottest cold fluid temperature greater than the coldest hot fluid temperature

How to improve the efficiency of the double pipe H.X?

☒ If a fluid with a poor heat transfer coefficient [oil or air] is to be cooled, an axially finned pipe can be placed inside of the larger pipe.

☒ Hairpin units can be connected in series or parallel to give the desired capacity.

Shell and Tube Heat Exchanger



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Heat Exchanger Important Notes

Allocation of fluids

Tube side

1. **Put dirty stream on the tube side [fouling fluid] - easier to clean inside the tubes**
2. **Put high pressure stream in the tubes to avoid thick, expensive shell**
3. **When special materials required for one stream, put that one in the tubes to avoid expensive shell**
4. **Put corrosive fluid in the tube tom reduce the cost of expensive shell**
5. **Put toxic fluid in the tube to minimize leakage**

Shell-Side

1. **Viscous fluid to increase (generally) the value of "U“ [Cross flow gives higher coefficients than in plane tubes, hence put fluid with lowest coefficient on the shell side]**
2. **Fluid having the lowest flow rate**
3. **Condensing or boiling fluid**

Start up and shut down procedure

Start up procedure

1. **Check all parts of the heat exchanger [no loose bolts, all valves in the shut position]**
2. **Testing the heat exchanger for leakage :**
   - **Hydrostatic test**
   - **Soap bubble test**
3. **Purging of the heat exchanger [before adding a liquid or a gaseous hydrocarbon to an exchanger inert gas is used to remove air or liquids from the exchanger to avoid the possibility of explosion]**
4. **Any temperature change should be made slowly because the shell and the tubes are made of different materials and do expand at different rates causing the tubes to be loosened from the tube sheet or may be broken or ruptured so during start up <u>cold fluid</u> is introduced first, <u>then hot fluid</u> is gradually added and the heat exchanger is brought to the operating temperature.**

Shut down procedure

- **During shutdown, the flow of hot fluid is stopped first. With no input of the hot fluid the heat exchanger gradually cools. Then the flow of cold fluid is stopped**
- **a liquid expands when it is heated and its volume increase. If the expanding liquid is enclosed, it exerts force or pressure on its container. Therefore a filled exchanger which is valved closed can be damaged by expanding fluid.**

Heat exchangers problems

- **Exchanger fouling**
- **Corrosion**
- **Vibration**

☒ *Fouling Problem*

Definition of fouling

Build up of various kinds of deposits on the parts of an exchanger

Types of fouling

1. **Salt deposit [as Ca and Mg deposits in case of hard water]**
2. **Chemical fouling [as corrosion products]**
3. **Biological fouling [as growth of algae which form insulating layer]**
4. **Coking**

Effect of fouling on the H.X performance

1. **Increase the thermal resistance and reduce the rate of heat transfer [decrease the efficiency of the H.X]**
2. **Increase the surface roughness [the flow of the fluid is restricted] and increase the pressure drop**

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Troubles that indicate the presence of fouling

1. Change in temperature or pressure
2. Change in flowrate [outlet flow rate]

Factors affecting the kind and degree of fouling

1. The materials used in the heat exchanger

- Some materials corrode faster than others providing corrosion products which decrease heat transfer
- Rough surface provides cavities for the build up of deposits

2. Fluid velocity

- Affect the fouling rate [as the velocity increase the fouling rate decrease]

How to handle the problem of fouling

- Antifoulants prevent the formation of deposits
- Inhibitors [as corrosion inhibitors] prevent chemical reactions
- which might cause deposits to build up
- Frequent cleaning of the H.X [maintenance]

Corrosion of heat exchangers

- Another series problem in heat exchangers is corrosion
- Severe corrosion can and does occur in tubes and very often with common fluids such as water

To avoid corrosion

- Proper material selection based on full analysis of the operating fluids, velocities and temperatures is a must
- Heavier gauge tubing is specified to offset the effect of corrosion followed by proper start up operating and shut down procedure
- Protection of the heat exchanger from corrosion [e.g.cathodic protection]
- Treatment of the cooling water used and using of inhibitors

Heat exchangers vibration

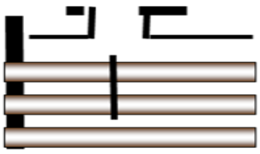
- Vibration of the tubes as a result of the flow of the shell side past them is important phenomena specially when the H.X size and flow quantities of flow are increased

Vibration effects

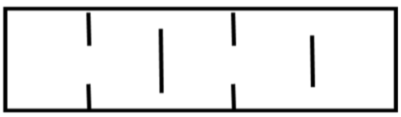
- Vibration has a bad effect on both tubes and shell
- The joints between the tubes and tube sheet can fail due to vibration causing leakage
- It causes leakage in the joints between shell and tubes
- Increase the shut down time to repair the H.X

Factors affecting tube vibration

- Tubes geometry [layout]
- Material of construction
- Means of support
- Heat exchanger size
- Flow quantities



Inlet support baffles



Double-segmental baffles

How to avoid vibration

- Using inlet support baffles
- Using double segmental baffles [improve tube support]
- Using j shell type [divided flow type to reduce the shell velocity]

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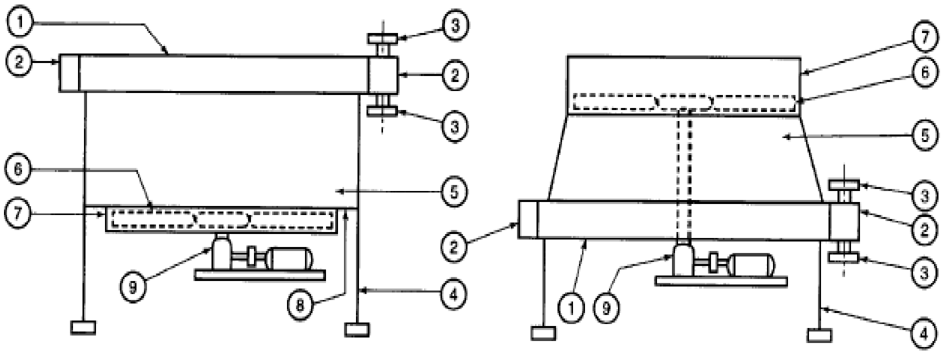
Air cooled heat exchanger

- Used for cooling and condensation and used when cooling water is in short supply or expensive
- Most common used in petroleum and gas processing industries

Air cooled exchangers consist of banks of finned tubes over which air is blown or drawn by fans mounted below or above the tube
If the fan is mounted below the tubes the unit is termed forced draft unit and if the fan is mounted above the tubes the unit is termed induced daft



(A) Forced Draft (B) Induced Draft

Legend

1. Tube bundle
2. Header
3. Nozzle
4. Supporting column
5. Plenum
6. Fan
7. Fan ring
8. Fan deck
9. Drive assembly

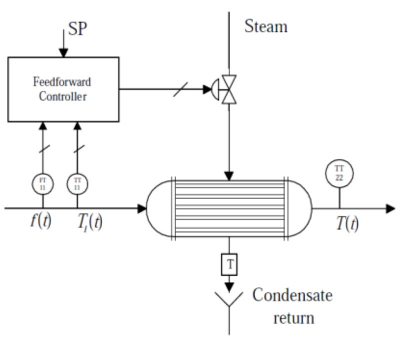
Forced Draft Air Cooler

- Less power is required
- Offer better accessibility to the fan for on stream maintenance
- Structural costs are less than induced draft since the fan is not exposed to the hot air
- Mechanical life is longer

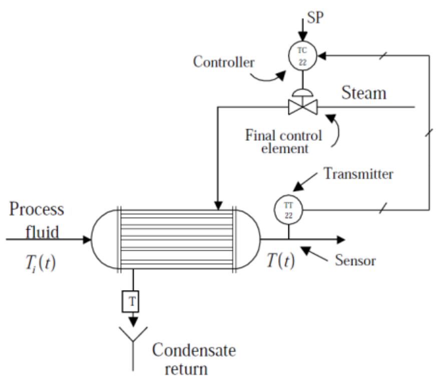
Induced Draft Air Cooler

- Provide more even distribution of air across the bundle, since air velocity approaching the bundle is relatively low
- This design permits close approach of the product temperature to ambient air temperature
- In service in which sudden temperature change would cause upset and loss of product, the induced draft unit gives more protection in that only a fraction of the surface is exposed to rainfall

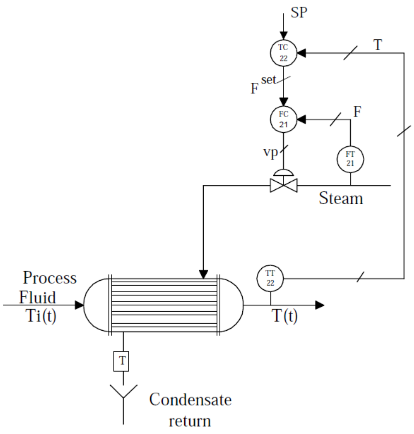
Heat exchangers control philosophy



Feed Forward Control for shell and tube



Feedback Control for shell and tube



Cascade Control With Flow Loop

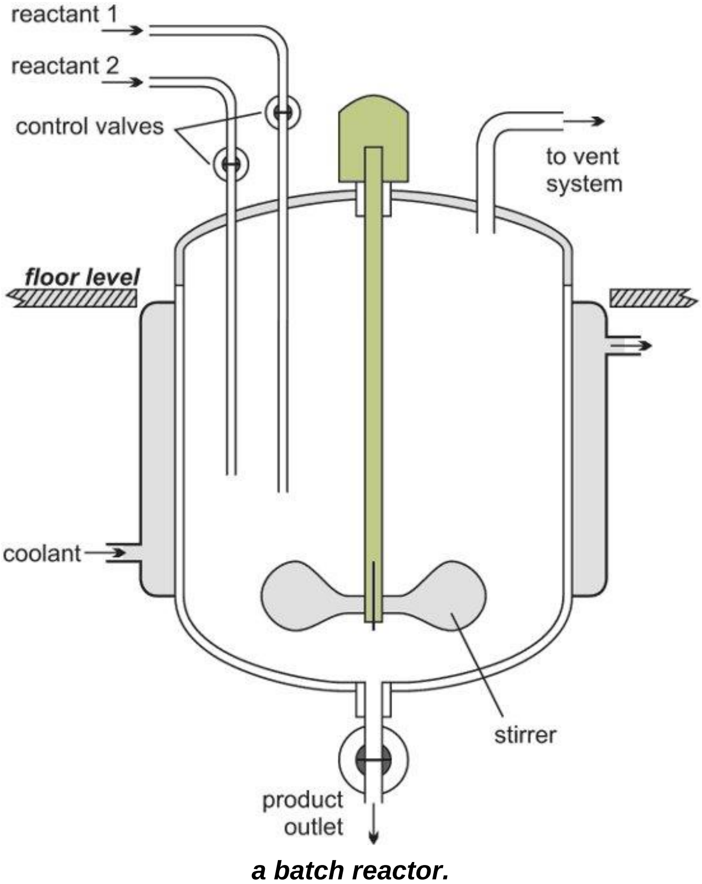
Chemical Reactors

The reactors, in which chemicals are made in industry, vary in size from a few cm^3 to the vast structures that are often depicted in photographs of industrial plants. For example, kilns that produce lime from limestone may be over 25 metres high and hold, at any one time, well over 400 tonnes of materials. The design of the reactor is determined by many factors but of particular importance are the thermodynamics and kinetics of the chemical reactions being carried out .

The two main types of reactor are termed *batch* and *continuous*.

Batch reactors

Batch reactors are used for most of the reactions carried out in a laboratory. The reactants are placed in a test-tube, flask or beaker. They are mixed together, often heated for the reaction to take place and are then cooled. The products are poured out and, if necessary, purified.
This procedure is also carried out in industry, the key difference being one of size of reactor and the quantities of reactants.



a batch reactor.

Following reaction, the reactor is cleaned ready for another batch of reactants to be added.

Batch reactors are usually used when a company wants to produce a range of products involving different reactants and reactor conditions. They can then use the same equipment for these reactions. Examples of processes that use batch reactors include the manufacture of colorants and margarine.

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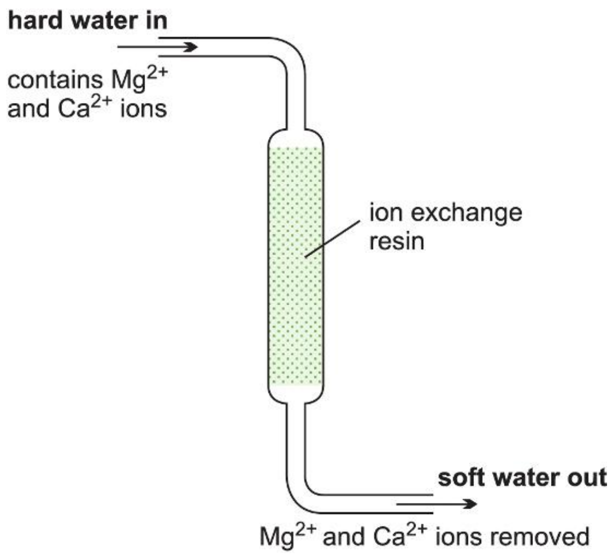
Continuous reactors

An alternative to a batch process is to feed the reactants continuously into the reactor at one point, allow the reaction to take place and withdraw the products at another point. There must be an equal flow rate of reactants and products. While continuous reactors are rarely used in the laboratory, a water-softener can beregarded as an example of a continuous process. Hard water from the mains is passed through a tube containing an ion-exchange resin. Reaction occurs down the tube and soft water pours out at the exit.



a continuous reactor.

Continuous reactors are normally installed when large quantities of a chemical are being produced. It is important that the reactor can operate for several months without a shutdown.

The residence time in the reactor is controlled by the feed rate of reactants to the reactor. For example, if a reactor has a volume of 20 m3 and the feed rate of reactants is 40 m3 h-1 the residence time is 20 m3 /40 m3 h-1 = 0.5 h. It is simple to control accurately the flow rate of reactants. The volume is fixed and therefore the residence time in the reactor is also well controlled.

The product tends to be of a more consistent quality from a continuous reactor because the reaction parameters (e.g. residence time, temperature and pressure) are better controlled than in batch operations.

They also produce less waste and require much lower storage of both raw materials and products resulting in a more efficient operation. Capital costs per tonne of product produced are consequently lower. The main disadvantage is their lack of flexibility as once the reactor has been built it is only in rare cases that it can be used to perform a different chemical reaction.

Types of continuous reactors

Industry uses several types of continuous reactors.

(a) Tubular reactors

In a tubular reactor, fluids (gases and/or liquids) flow through it at high velocities. As the reactants flow, for example along a heated pipe, they are converted to products . At these high velocities, the products are unable to diffuse back and there is little or no back mixing.

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The conditions are referred to as plug flow. This reduces the occurrence of side reactions and increases the yield of the desired product.

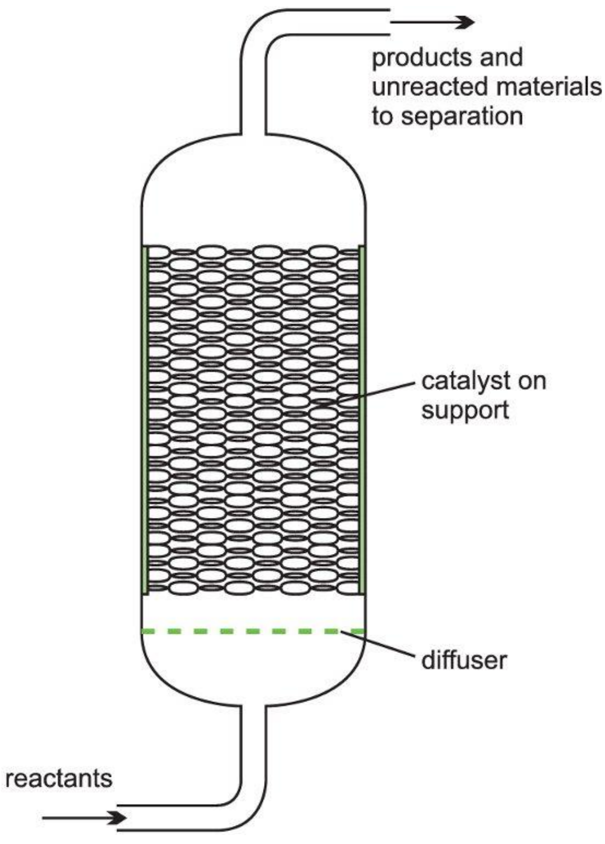
With a constant flow rate, the conditions at any one point remain constant with time and changes in time of the reaction are measured in terms of the position along the length of the tube.

The reaction rate is faster at the pipe inlet because the concentration of reactants is at its highest and the reaction rate reduces as the reactants flow through the pipe due to the decrease in concentration of the reactant. Tubular reactors are used, for example, in the **steam cracking** of ethane, propane and butane and naphtha to produce alkenes.

(b) Fixed bed reactors

A heterogeneous catalyst is used frequently in industry where gases flow through a solid catalyst (which is often in the form of small pellets to increase the surface area). It is often described as a fixed bed of catalyst

Among the examples of their use are the manufacture of sulfuric acid (the Contact Process, with vanadium(V) oxide as catalyst), the manufacure of nitric acid and themanufacture of ammonia (the Haber Process, with iron as the catalyst).



a fixed bed reactor.

A further example of a fixed bed reactor is in catalytic reforming of naphtha to produce branched chain alkanes, cycloalkanes and aromatic hydrocarbons using usually platinum or a platinum-rhenium alloy on an alumina support.

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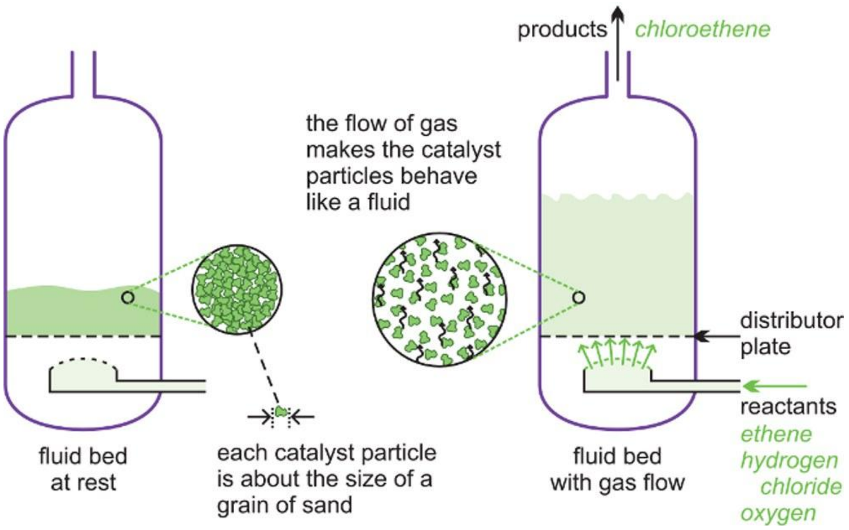
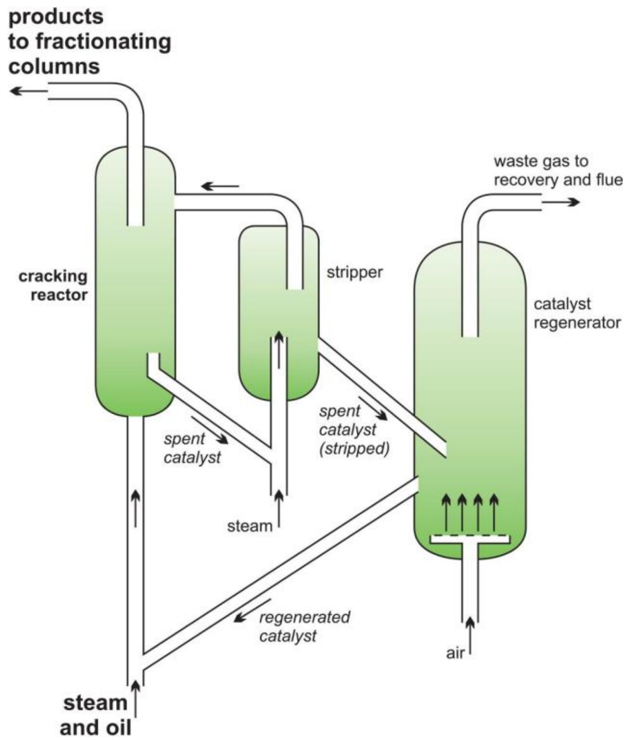
(c) Fluid bed reactors

A fluid bed reactor is sometimes used whereby the catalyst particles, which are very fine, sit on a distributor plate. When the gaseous reactants pass through the distributor plate, the particles are carried with the gases forming a fluid . This ensures very good mixing of the reactants with the catalyst, with very high contact between the gaseous molecules and the catalyst and a good heat transfer. This results in a rapid reaction and a uniform mixture, reducing the variability of the process conditions.

One example of the use of fluid bed reactors is in **the oxychlorination of ethene to chloroethene (vinyl chloride),** the feedstock for the polymer poly(chloroethene) (PVC). The catalyst is copper(II) chloride and potassium chloride deposited on the surface of alumina. This support is so fine, it acts as a fluid when gases pass through it.



Another example is **the catalytic cracking of gas oil** to produce **alkenes (ethene and propene)** and petrol with a high octane rating.



A catalytic cracker as used to produce alkenes from gas oil.

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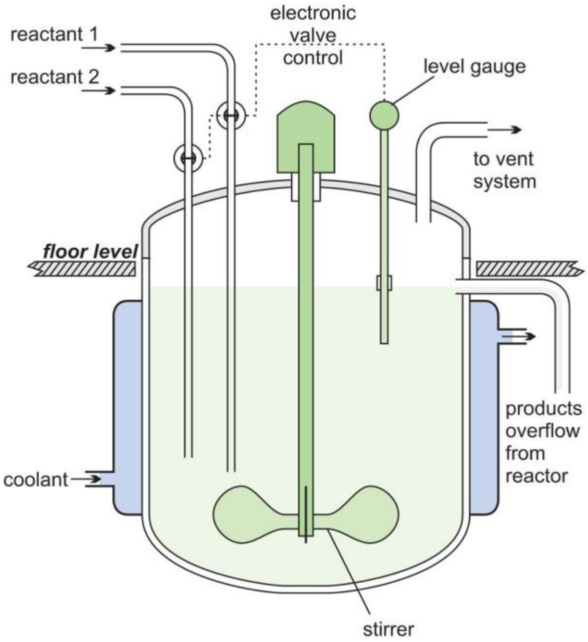
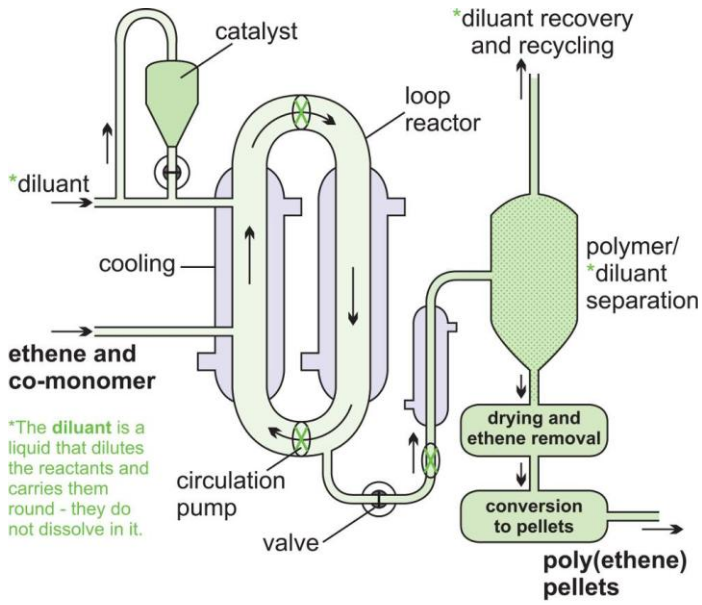
(d) Continuous stirred tank reactors, CSTR

In a CSTR, one or more reactants, for example in solution or as a slurry, are introduced into a reactor equipped with an impeller (stirrer) and the products are removed continuously. The impeller stirs the reagents vigorously to ensure good mixing so that there is a uniform composition throughout. The composition at the outlet is the same as in the bulk in the reactor. These are exactly the opposite conditions to those in a tubular flow reactor where there is virtually no mixing of the reactants and the products.



a continuous stirred tank reactor.

A CSTR reactor is used, for example in the production of the amide intermediate formed in the process to produce methyl 2-methylpropenoate. Sulfuric acid and 2-hydroxy-2-methylpropanonitrile are fed into the tank at a temperature of 400 K. The heat generated by the reaction is removed by cooling water fed through coils and the residence time is about 15 minutes. A variation of the CSTR is the loop reactor which is relatively simple and cheap to.



Loop reactors are used, for example, in the manufacture of poly(ethene) and the manufacture of poly(propene). Ethene (or propene) and the catalyst are mixed, under pressure, with a diluent, usually a hydrocarbon.

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Valves

Definition

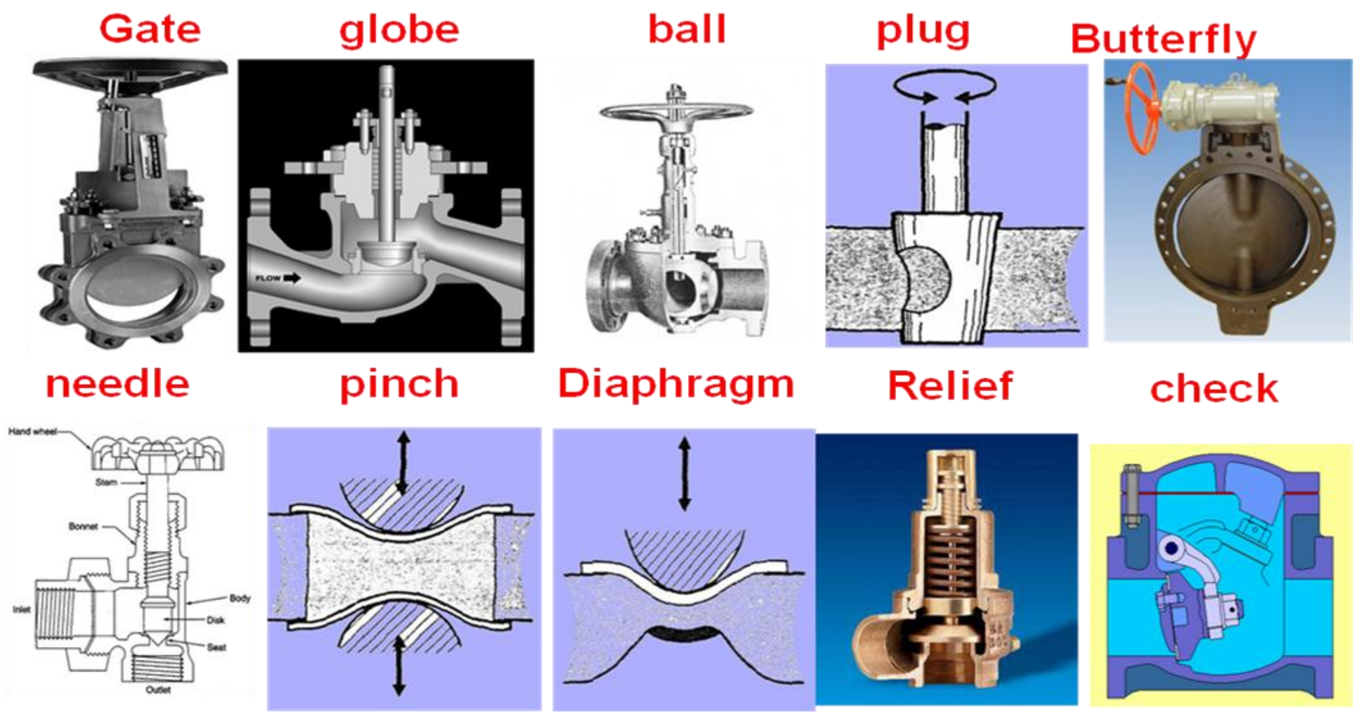
Devices which control the amount and direction of fluid flow in piping systems .
Typically made of bronze, brass, iron, or steel alloy .

Components:

- Valve body	**- Packing**	**- Disc**	**- Packing gland/nut**
- Seat	**- Stem**	**- Bonnet**	**- Wheel**

Types :

- **On-Off Service**
- **Throttling (Regulating) Service**
- **Prevention of back flow**
- **Pressure control (Control Valve)**



On-Off Service "Block Valves "

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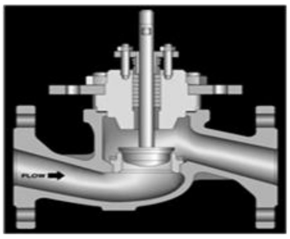
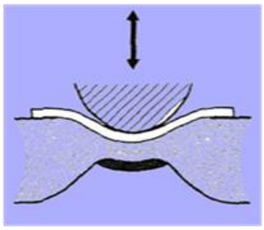
Throttling (Regulating) Service

globe

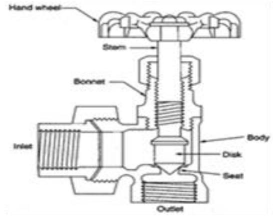


butterfly

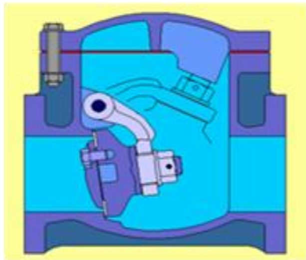
diaphragm



needle



Non – Return (Or Check) Valves

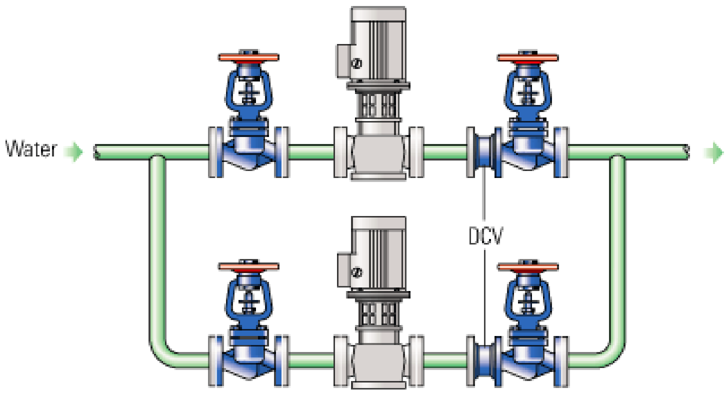


Pressure control (Control Valve)

Control system would normally consist of the following components:

- Control valves.
- Actuators.
- Controllers.
- Sensors.

Valve Position



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Chapter 5

Units Measurements

وحدات القياس

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Quantity	SI unit	Symbol	الوحدة	الكمية
Length	metre	m	متر	الطول
Mass	kilogram	kg	كيلوجرام	الوزن
Time	second	s	ثانية	الوقت
Electric current	ampere	A	أمبير	التيار الكهربي
Temperature	kelvin	K	كلفن	درجة الحرارة
Amount of substance	mole	mol	مول	كمية المادة
Luminous Intensity	candela	cd	شمعة	شدة الإضاءة

SI Derived Units

Quantity	SI unit	Symbol	الوحدة	الكمية
Frequency	hertz	Hz	هيرتز	التردد
Force	newton	N	نيوتن	القوة
Pressure, stress	pascal	Pa	باسكال	الضغط
Energy, work, Heat Quantity	joule	J	جول	الطاقة،الشغل،كمية الحرارة
Power, radiant flux	watt	W	وات	القوة
Electric charge	coulomb	C	كولوم	الشحنة الكهربائية
EMF	volt	V	فولت	القوة الدافعة الكهربية
Electric Capacitance	farad	F	فاراد	السعة الكهربائية
Electric Resistance	ohm		أوم	المقاومة الكهربائية
Electric Conductance	siemens	S	سيمنز	التوصيل الكهربي
Magnetic Flux	weber	Wb	ويبر	المجال المغنطيسي
Magnetic Flux Density	tesla	T	تسلا	كثافة المجال المغنطيسي
Inductance	henry	H	هنري	
Luminous Flux	lumen	lm	لومن	
Illuminance	lux	lx	لكس	الإضاءة

Units other than SI

Quantity	Unit	Symbol	الوحدة	الكمية
Length	inch	in	بوصة	الطول
	feet	ft	قدم	
Mass	ton	t	طن	الكتلة
	pound	lb	رطل	
Time	minute	min	دقيقة	الوقت
	hour	h	ساعة	
	day	d	يوم	
	annum	a	سنة	
Temperature	Degree Fahrenheit	°F	درجة فهرنهايت	درجة الحرارة
	Degree Centigrade	°C	درجة مئوية	

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Units other than SI

Volume	barrel	bbl	برميل	الحجم
	US gallon	US gal	جـــــــالون أمريكي	
	standard cubic feet	scf	قـــدم مكعـــب قياسي	
Flow Rates	Barrel/day	bbl/d	برميل/يوم	معدل السريان
	US gallon/day	US gal/min	جـــــــالون أمريكي/يوم	
	standard cubic feet/day	scf/d	قـــدم مكعـــب قياسي/يوم	
Mass Rates		t/h	طن/ساعة	معدل حركة الكتلة
		t/	طن/يوم	
Pressure		psia		الضغط
		psig		
Pressure drop		psi		فرق الضغط
Small quantities		ppm		الكميات الدقيقة
Oil/Gas ratio		bbl/MMscf		نسبة الزيت للغاز
Gas/Oil ratio		scf/bbl		نسبة الغاز للزيت
Other		BTU		وحدة حرارية إنجليزية
		rpm		عدد اللفات في الدقيقة
		HP		حصان ميكانيكي

Prefixes

Quantity	Factor	Symbol	الكمية
Thousand	10^3	M	ألف
Million	10^6	MM	مليون
Trillion	10^{12}	T	تريليون

STANDARD CONDITIONS الظروف القياسية

English			Metric		
Pressure	Temperature	Molal Volume	Pressure	Temperature	Molal Volume
14.696 psia	60°F	379.3ft³/lb mol	100 kPa	15°C	23.66 m3/kmol
14.65	60	380.5	100	0	22.71
14.73	60	378.4	101.325	15	23.64
14.50	60	384.4	101.325	0	22.41

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Basic conversion Factors معاملات التحويل الأساسية

LENGTH
الطول

1m=3.281 ft=39.37 in.=100 cm=1000 mm

1 ft=0.305 m=12 in.=30.5 cm=305 mm

1 statute mile=1.61 km, 1 km=0.621 statute mile

AREA
المساحة

1 m^2=10,000 cm^2=10.76 ft^2=1549 $in.^2$

1 hectare=10,000 m^2=2.47 acres

1 sq mile (section)=2.59 km^2

VOLUME
الحجم

1 m^3=35.31 ft^3=6.29 bbl=1000 L

1 L=0.001 m^3=1000 cm^3=0.035 ft^3=61 $in.^3$

1 ft^3=0.0283 m^3=28.3 L

1 bbl (API)=0.159 m^3=159 L=5.61 ft^3

MASS
الكتلة

1 kg=2.205 lb=1000 g

1 lb=0.454 kg=454 g

1 ton (metric)=1000 kg=2205 lb_m=1 Mg

DENSITY
الكثافة

1 kg/m^3=0.001 g/cm^3=0.0624 lb/ft^3

1 lb/ft^3=16.02 kg/m^3=0.01602 g/cm^3

1 g/cm^3=1000 kg/m^3=62.4 lb/ft^3=1.0 kg/L

FORCE
القوة

1 N=0.225 lb_f=0.102 kg_f

1 kg_f=9.81 N=2.205 lb_f

1 lb_f=4.45 N=0.454 kg_f

PRESSURE
الضغط

1 bar=14.50 psi=0.987 atm=1.02 kg/cm2

=100,000 N/m2=0.454 kg_f

1 psi=6.895 kPa

TEMPERATURE
الحرارة

^oC=0.556(^oF-32), K=^oC+273

^oF=(1.8)(^oC)+32, ^oR=^oF+460

CONVERSION BETWEEN UNITS التحويل بين الوحدات

1 std f3 (@ 60 ^oF and 14.7 psia)=0.0286 std m3 (@ 15 ^oC and 100 kPa)

1 std m3 (@ 15 ^oC and 100 kPa)=34.92 std ft3 (@ 14.7 psia and 60 ^oF)

1 bbl=159 L=0.159 m^3

1 m^3=35.3 ft^3 liquid=264 US gal=220 UK gal=6.29 bbl

1 L=0.264 US gal=0.22 UK gal=0.0353 ft^3

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Chapter 6
Important Appreciations
اختصارات هامة

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REGULARLY USED ABBREVIATIONS

A	Absolute (Pressure or Temperature)
ASME	Ameriacan Standard for Mechanical Engineers
ABS	Asphalt Burning System
AFQRJOS	Aviation Fuel Quality Requirements for Jointly Operated Systems
AFRA	Average Freight Rate Assessment
AGST	Authorised Gas Safety Tester
AGO	Automotive Gas Oil
AIP	Australian Institute of Petroleum
AN	Asset North
AO	Asset Offplot
AOC	Accidentally Oil Contaminated Sewer
APC	Advanced Process Control.
API	American Petroleum Institute
ARPS	Asset Release Permit Signatory
AS	Asset South
ASA	Anti-static Additive
ASTM	American Society for Testing Materials
ATCE	Average Total Capital Employed
ASU	Air Separation Unit
ANSI	American National Standards Institute
AFFF	Aqueous Film-Forming Foam

B

BA	Breathing Apparatus
BBL	Barrel
BBL	Block Battery Limit
BBU	Blown Bitumen Unit
BCW	Boiler Circulation Water
BDU	Butane Deasphalt Unit
BFW	Boiler Feed Water
BHP	Brake Horse Power
BOD	Biochemical Oxygen Demand
BS&W	Basic Sediment & Water
BTHU, BTU	British Thermal Unit

C

^oC	Centigrade (or Celsius)
CAD	Computer Aided Design
CBD	Continous Blow Down
CAM	Computer Aided Management
CASS	Critical Activity Specification Sheet.

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CD	Crude Distiller
CEL	Corrected Energy and Loss
CFPP	Cold Filter Plugging Point
CFR	Combined Feed Ratio
CFR	Co-operative Fuel Research Council
CO	Cooling Oil
CO	Carbon Monoxide
CCR	Central Control Room
CO2	Carbon Dioxide
COC	Continuously Oil Contaminated Sewer
COD	Chemical Oxygen Demand
COW	Crude Oil Wash
CP	Centipoise
CPA	Critical Path Analysis
CPR	Cardio Pulmonary Resuscitation
CPSL	Competitive Price and Supply Level
CR	Compression Ratio
CRI	Criteria Referenced Instruction
CS	centistokes
CTL	Coastal Tankers Ltd
CW	Cooling Water
CWD	Combined Waxy Distillate
CNG	Compressible Natural Gas

D

DAO	De-asphalted Oil
dB(A)	Scale for measuring all levels of Noise
DCF	Discounted Cash Flow
DEP	Design & Engineering Practice
DERD	Min of Defence Directorate of Engines
DERV	Diesel Engined Road Vehicle
DFE	Di-Fluoro Ethylene
DIPA	DI Iso Propanol Amine
DMDS	Di Methyl Di Sulphide
DOL	Department Of Labour
DRG	Drawing
DWT	Dead Weight Tons
DEA	Diethanolamine
DEG	Diethylene glycol
DCS	Distribution Control System.
DCN	Design Concern

E

ECC	**Employee Consultative Committee**
EMPRV	**Maintenance planning & Scheduling system used at NZRC.**
ENCHEM	**Energy & Chemical Plant (NZQA National Certificate levels 2 & 4)**
EOR	**End of Run**
EPC	**Enhanced Process Control.**
ESO	**Emergency Shut Off**
ETA(D)	**Estimated Time of Arrival (Departure)**
EG	**Ethylene glycol**
EOR	**End of Run / Enhanced Oil Recovery**
FMEA	**Failure Modes and Effects Analysis**

F

^oF	**Fahrenheit**
FBP	**Final Boiling Point**
FC	**Foecal Coliform**
FIFO	**First In First Out**
FMA	**Free Mineral Acidity**
FO	**Flushing Oil**
FOB	**Free On Board**
FOR	**Flushing Oil Return**
FOS	**Flushing Oil Supply**
FAT	**Factory Acceptance Test**
FVI	**Flexible Volatility Index**

G

GLC	**Gas Liquid Chromatography**
GCWR	**Gland Cooling Water Return**
GCWS	**Gland Cooling Water Supply**
GM	**General Manager**
GRM	**Gross Refiners Margin**
GSC	**Gas Solid Chromatography**
GSP	**Government Selling Price**
GOV	**Gas Operated Valve**
GTL	**Gas To Liquid**
GRP	**Glass Reinforced Plastic**

H

HCC	**Hydrocarbon Collecting System**
HCU	**Hydrocracker Unit**
HBFW/HHFW	**HP Boiler Feed Water**
HDS	**Hydrodesulphuriser**
HDT	**Hydrotreater**
HITLOP	**High Temperature Low Pressure**

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HMU	**Hydrogen Manufacturing Unit**
HR	**Human Resources**
HSE	**Health, Safety & Environment**
HTS	**High Temperature Shift**
HVI	**High Viscosity Index**
HVU	**High Vacuum Unit**
HWD	**Heavy Waxy Distillate**
H_2S	**Hydrogen Sulphide**
HAZMAT	**Hazardous Materials Response Division**
HSE	**Health, Safety and Environment**
HAZOP	**Hazard & Operability Studies**

I

IBP	**Initial Boiling Point**
ICA	**Ignition Control Additive**
ID	**Internal Diameter**
IGS	**Inert Gas System**
IP	**Institute of Petroleum**
ISP	**Information Systems Planning**

J

JFTOT	**Jet Fuel Thermal Oxidation Test**
JSA	**Job Safety Analysis**

K

K	**Kelvin (temperature scale)**
KHT	**Kerohydrotreater**
KHDS	**Kerosene Hydrodesulphuriser**
KSLA	**Koninklijke Shell Laboratorium Amsterdam (Shell Research Centre)**
kWh	**Kilowatt Hour**

L

LEL	**Lower Explosive Limit**
LHSV	**Liquid Hourly Space Velocity**
LIFO	**Last In First Out**
LNG	**Liquefied Natural Gas**
LOIT	**Local Oil Inland Trade**
LEL	**Lower Explosive Limit**
LVI	**Low Viscosity Index**
LTI	**Loss Time Injury**
LP	**Linear Programme**
LPG	**Liquefied Petroleum Gas**
LTI	**Lost Time Injury**
LTS	**Low Temperature Shift**

LWD	**Light Waxy Distillate**
ID	**Inner Diameter**
ISO	**International Standards Organization**
IBD	**Intermittent Blow Down**

M

MCF	**Methyl Chloroform**
MESC	**Material and Equipment Standards and Code**
MDFI	**Mid Distillate Flow Improper**
MLSS	**Mixed Liquor Suspended Solids**
MMI	**Man Machine Interface**
MON	**Motor Octane Number**
MOV	**Motor Operated Valve**
MOC	**Moment Of Change**
MPMP	**Multi Period Multi Product**
MSDS	**Material Safety data Sheets**
MVI	**Medium Viscosity Index**
MDEA	**Methyldiethanolamine**
MEA	**Monoethanolamine**
MAWP	**Maximum Allowable Working Pressure**
MMscfd	**Million Standard Cubic Feet Per Day**

N

NaOH	**Sodium Hydroxide (Caustic Soda)**
NGL	**Natural Gas Liquids**
NHDT	**Naptha Hydrotreater**
NH_3	**Ammonia**
NIAT	**Net Income After Tax**
NIBT	**Net Income Before Tax**
NNF	**Normally No Flow**
NPV	**Net Present Value**
NRV	**Non Return Valve**
NSHP	**Net Suction Head Pressure**
NZRC	**The New Zealand Refining Company Ltd**
NZQA	**New Zealand Qualifications Authority**
NFPA	**National Fire Protection Agency**
NDT	**Non-Destructive Testing**

O

OEL	**Occupational Exposure Limit**
OD	**Outside Diameter**
OPCO	**Operating Company**
OPEC	**Organisation of Petroleum Exporting Countries**
OSH	**Occupational Safety & Health**

P

PAG	Project Approval Group
PCA	Polycyclic Aromatic
PCR	Plant Change Request
PEFS	Process Engineering Flow Scheme
PEUFS	Process Engineering Utilities Flow Scheme
PFS	Process Flow Scheme
PH	Power of Hydrogen Ion
PICW	Person in Charge of Work
PID	Proportional, Integral, Derivative
PITO	Petrochemical Industry Training Organisation
PK	Premium Kero
PLS	Production Laboratory Standing Instructions
PM	Pensky Martin
PM	Planned Maintenance
PM	Preventive Maintenance
PON	Petroleum Operations Notice
PTW	Permit To Work
PL	Punsh List
PLC	Programable Logic Control
PFD	Process Flow Diagram
P&ID	Piping and Instrumentation Diagram
PONA	Paraffins, Olefins, Naphthenes, Aromatics
PROSS	Process Control and Supervisory System
PRT	Power Recovery Turbine
PPE	Personal Protective Equipment
PPM(b)	Parts per Million (billion)
PPI	Parallel Plate Interceptor
PPR	Plant Project Request
PSA	Pressure Swing Adsorption
PSFS	Process Safeguarding Flow Scheme
PSIA(G)	Per Square Inch Absolute (gauge)
PSV	Pressure Safety valve
PTW	Permit to Work
PV	Process variable
PSV	Pressure Safety Valve
PCV	Pressure Control Valve

O

QMI	Quality Measuring Instrument

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R

RAP	**Refinery Auckland Pipeline**
RBU	**Refinery Business Unit**
RCU	**Remote Control Unit**
RFB	**Regenerable Free Base**
RFL	**Refinery Fuel and Loss**
RFSU	**Ready For Start Up**
RIF	**Report Input Form**
RON	**Research Octane Number**
ROV	**Remote Operated Valve**
RPM	**Revolutions Per Minute**
RSI	**Refinery Steering Instructions.**
RTU	**Remote Terminal Unit**
RUPIA	**Residue Upgrading Performance Index Actual**
RV	**Relief Valve**
RVP	**Reid Vapour Pressure**
RPM	**Revolutions Per Minute**
RT	**Radiographic Test for Welding**
RFI	**Request For Inspection**

S

SAC	**Strong Acid Cation**
SAE	**Society of Automotive Engineers**
SAFETNET	**Computer Database system used by NZRC to store HSE information**
SBA	**Strong Base Anion**
SCADA	**Supervisory Control and Data Acquisition**
SCBA	**Self Contained Breathing Apparatus**
SCR	**Software Change Request**
SD	**Shutdown**
SDWT	**Short Dead Weight Tons**
SG	**Specific Gravity**
SOR	**Start of Run**
SAT	**Site Acceptance Test**
STO	**Safe To Operate (Certificate)**
SCF	**Standard Cubic Foot of Natural Gas**
SOP	**Standard operating procedure**
SOC	**Special Operating Condition**
SI	**Standing Instruction**
SIOP	**Shell International Oil Products**
SMOC	**Shell Multi Verbal Optimising Control**
SO	**Seal Oil**
$SO_2(O_3)$	**Sulphur Dioxide (trioxide)**
SOR	**Start of Run**

SP	**Set Point**
SPL	**Sound Pressure Level**
SRF	**Standard Refinery Fuel**
SRU	**Sulphur Recovery Unit**
STEL	**Short Term Exposure Limit**
SSV	**Settled Sludge Volume**
SU	**Start Up**
SVI	**Sludge Volume Index**
SWL	**Safe Working Load**
SWS	**Sour Water Stripper**

T

TAB	**Total Aerobic Bacteria**
TBP	**True Boiling Point**
TDC	**Total Distributed Control**
TDS	**Total Dissolved Solids**
TEL	**Tetraethyl Lead (Not used any more)**
TEG	**Triethylene glycol**
T4EG	**Tetraethylene glycol**
TLF	**Truck Loading Facility**
TOC	**Total Organic Carbon**
TCF	**Trillion Cubic Feet of NG**
TQM	**Total Quality Management**
TEA	**Triethanolamine**
T/SD	**Tonnes Per Stream Day**
TSO	**Tight Shut Off (Valve)**

U

UEL	**Upper Explosive Limit**
US	**Un-Serviceable**

V

VGO	**Vacuum Gas Oil**
VLCC	**Very Large Crude Carrier**
VMLSS	**Volatile Mixed Liquor Suspended Solids**
VFD	**Variable Frequency Drive**

W

WABT	**Weighted Average Bed Temperature**
WHB	**Waste Heat Boiler**
WHSV	**Weight Hourly Space Velocity**
WOSL	**Wiri Oil Services Ltd**
WWT	**Waste Water Treatment**

Y

YP	**Yard Pipe**

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Chapter 7
Important Definitions
مصطلحات هامة

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Distillation is defined as:
a process in which a liquid or vapour mixture of two or more substances is separated into its component fractions of desired purity, by the application and removal of heat.
Distillation is based on the fact that the vapour of a boiling mixture will be richer in the components that have lower boiling points.

Vapour Pressure and Boiling
The vapour pressure of a liquid at a particular temperature is the equilibrium pressure exerted by molecules leaving and entering the liquid surface. Here are some important points regarding vapour pressure.

Absorber
A tower or column that provides contact between natural gas being processed and a liquid solvent

Absorption Factor
The operation in which one or more components in the gas phase are transferred to (absorbed into) a liquid solvent
A factor which is an indication of the tendency for a given gas phase component to be transferred to the liquid solvent. It is generally expressed as A = L/KKV where L and V are the moles of liquid and vapor, and K is the average value of the vapor liquid equilibrium constant for the component of concern.

Absorption Oil
A hydrocarbon liquid used to absorb and recover components from the natural gas being processed.

Acid Gas
The hydrogen sulfide and/or carbon dioxide contained in, or extracted from, gas or other streams.

Adiabatic Expansion
The expansion of a gas, vapor, or liquid stream from a higher pressure to a lower pressure in which there is no heat transfer between the gas, vapor, or liquid and the surroundings.

Adsorbent
A solid substance used to remove components from natural gas being processed.

Adsorption
The process by which gaseous components are adsorbed on solids because of their molecular attraction to the solid surface

Amine (alkanolamine)
Any of several liquid compounds containing amino nitrogen generally used in water solution to remove, by reversible chemical reaction hydrogen sulfide and/or carbon dioxide from gas and liquid hydrocarbon stream

Associated Gas
Gaseous hydrocarbons occuring as a free-gas phase under original oil-reservoir conditions of temperature and pressure.

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Atmospheric Pressure
The pressure exerted on the earth by the earth's atmosphere. A pressure of 760 mm of mercury or 101.3250 kPa is used as a standard for some measurements. State regulatory bodies have set other standards for use in measuring the legal volume of gas. Atmospheric pressure may also refer to the absolute ambient pressure at any given location.

Barrel
common English - unit measure of liquid volume which, in the petroleum industry, equals 42 U.S. liquid gallons for petroleum or natural gas liquid products measured at 60°F and equilibrium vapor pressure. One barrel equals 0.159 cubic meters, or 6.29 barrels per cubic meter (See Fig, 1-2).

Blanket gas
A gas phase maintained in a vessel containing liquid to protect the liquid against air contamination, to reduce the hazard of detonation, or to maintain pressure of the liquid. The source of the gas is external to the vessel.

Blow Case
A small tank in which liquid is accumulated and then forced from the tank by applying as or air pressure above the liquid level.

Blowdown
The act of emptying or depressuring a vessel. This may also refer to discarded material, such as blow down water from a boiler or cooling tower.

Boilaway Test
Sometimes used to describe the GPA weathering test for LPgas. Refer to the definition of weathering test

Bottoms
The liquid or residual matter which is withdrawn from the bottom of a fractionator or other vessel during processing or while in storage.

B-P mix
A liquefied hydrocarbon product composed chiefly of butanes and propane. If it originates in a refinery, it may also contain butylenes and propylene. More specifically, it conforms to the GPA specifications for commercial B-P mixes as described in GPA Standard 2140.

Breathing
The movement of vapor in or out of an atmospheric pressure storage tank because of a change of level of the stored liquid, a change in the temperature of the vapor space above the liquid, or a change of atmospheric pressure.

BS&W (basic sediment and water)
Waste that collects in the bottom of vessels and tanks containing petroleum or petroleum products.

Bubble Point
The temperature at a specified pressure at which the first stable vapor forms above a liquid.

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Commercial Butane,
A liquefied hydrocarbon consisting predominately of butane and/or butylene and which conforms to the GPA specification for commercial butane defined in GPA Standard 2140.

Calorimeter
An apparatus which is used to determine the heating value of a combustible material.

Normal Butane,
In commercial transactions, a product meeting the GPA specifications for commercial butane and, in addition, containing a minimum of95 liquid volume percent normal butane. Chemically, normal butane is an aliphatic compound of the paraffin series having the chemical formula C4HlO and having all of its carbon atoms joined in a straight chain.

Carbonyl Sulfide
A chemical compound of the aldehyde group containing a carbonyl group and sulfur (COS). Sometimes a contaminant in natural gas and NGL. It may need to be removed in order to meet sulfur specifications.

Casinghead Gas
Unprocessed natural gas produced from a reservoir containing oil. It contains heavier hydrocarbon vapors and is usually produced under low pressure from a casing head on the well.

Charcoal Test
A test standardized by the Gas Processors Association and the American Gas Association for determining the natural gasoline content of a given natural gas. The gasoline is adsorbed from the gas on activated charcoal and then recovered by distillation. The test is prescribed in Testing Code 101-43, joint publication of AGA and GPA.

Chromatography
A technique for separating a mixture into individual components by repeated adsorption and desorption on a confined solid bed. It is used for analysis of natural gas and NGL.

Claus Process
A process to convert hydrogen sulfide into elemental sulfur by selective oxidation.

Compressibility Factor
A factor, usually expressed as "Z," which gives the ratio of the actual volume of gas at a given temperature and pressure to the volume of gas when calculated by the ideal gas law.

Compression Ratio
The ratio of the absolute discharge pressure from a compressor to the absolute intake pressure. Also applies to one cylinder of a reciprocating compressor and one or more stages of a rotating compressor.

Condensate
The liquid formed by the condensation of a vapor or gas; specifically, the hydrocarbon liquid separated from natural gas because of changes in temperature and pressure when the gas from the reservoir was delivered to the surface separators. In a steam system it may be water that is condensed and returned to the boilers.

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Convergence Pressure

The pressure at a given temperature for a hydrocarbon system of fixed composition at which the vapor-liquid equilibrium K-values of the various components in the system become, or tend to become, unity. The convergence pressure is used to adjust vapor-liquid equilibrium K-values to the particular system under consideration.

Copper Strip Test

A test using a small strip of pure copper to determine qualitatively the hydrogen sulfide corrosivity of a product. Refer to GPA LP-gas copper strip test (Copper Strip Method), ASTM D-1838 test procedure.

Critical Density

The density of a substance at its critical temperature and critical pressure.

Critical Pressure

The vapor pressure of a substance at its critical temperature.

Critical Temperature

For a pure component, the maximum temperature at which the component can exist as a liquid.

Cryogenic Plant

A gas processing plant which is capable of producing natural gas liquid products, including ethane, at very low operating temperatures, usually below minus 50°C.

Cubic Meter

A unit of volume measurement commonly used in international commerce for petroleum, petroleum products and natural gas. One cubic meter measured at 15.56°C = 264.172 U.S. gallons = 6.29 barrels = 35.315 cubic feet measured at 15.56°C.

Deaerator

An item of equipment used for removing air or other non-condensible gases from a process stream or from steam condensate or boiler feed water.

Debutanizer

A fractionator designed to separate butane (and more volatile components if present) from a hydrocarbon mixture.

Dehydration

The act or process of removing water from gases or liquids.

Demethanized Product

A product from which essentially all methane and lighter materials have been removed.

Demethanizer

A fractionator designed to separate methane (and more volatile components if present) from a hydrocarbon mixture.

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Depropanizer
Afractionator designed to separate propane (and more volatile components if present) from a hydrocarbon mixture.

Desiccant
A substance used in a dehydrator to remove water and moisture. Also a material used to remove moisture from the air.

Desulfurization
A process by which sulfur and sulfur compounds are removed from gases or liquid hydrocarbon mixtures.

Dew Point
The temperature at any given pressure, or the pressure at any given temperature, at which liquid initially condenses from a gas or vapor. It is specifically applied to the temperature at which water vapor starts to condense from a gas mixture (water dew point), or at which hydrocarbons start to condense (hydrocarbon dew point).

Distillation
The process of separating materials by successively heating to vaporize a portion and then cooling to liquefy a part of the vapor. Materials to be separated must differ in boiling point and/or relative volatility.

Doctor Test
A qualitative method for detecting hydrogen sulfide and mercaptans in NGL. The test distinguishes between "sour" and "sweet" products.

Dry Gas
(1) Gas whose water content has been reduced by a dehydration process. (2) Gas containing little or no hydrocarbons commercially recoverable as liquid product. Gas in this second definition preferably should be called lean gas.

End Point
The maximum temperature observed on the thermometer during an ASTM distillation test.

EP-Mix (ethane-propane mix)
A product consisting of a mixture of essentially ethane and propane.

Expansion Turbine
A device which converts part of the energy content of a gas or liquid stream into mechanical work by expanding the gas or liquid through a turbine from which work is extracted.

Extraction
The process of transferring one or more components from one liquid phase to another by virtue of different solubility in the two liquids. It is also used to indicate removal of one or more constituents from a stream.

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Field Separator
A vessel in the oil or gas field for separating gas, hydrocarbon liquid, and water from each other.

Flash Point
The lowest temperature at which vapors from a hydrocarbon liquid will ignite. See ASTM D-56.

Fractionation
See definition of "distillation." Generally used to describe separation of a mixture of hydrocarbons into individual products based on difference in boiling point and/or relative volatility.

Freeze Valve
A specially constructed and calibrated valve designed and used solely for determining the water content in propane product. See ASTM D-2713.

Gas Constant (R)
The constant multiplier in the Ideal Gas Law. Numerically, R=PV/T, if V is the volume of one mole of an ideal gas at temperature T and pressure P.

Gas Hydrate
Refer to definition of "hydrate".

Gas Injection
The injection of natural gas into a reservoir to maintain or increase the reservoir pressure or reduce the rate of decline of the reservoir pressure.

Gas Lift
A method for bringing crude oil or water to the surface by injecting gas into the producing well bore.

Gas-Oil Ratio (GOR)
The ratio of gas to liquid hydrocarbon produced from a well. This may be expressed as standard cubic meters of gas per cubic meter of stock tank liquid.

Gas Processing
The separation of constituents from natural gas for the purpose of making salable products and also for treating the residue gas to meet required specifications.

Gas Processing Plant
A plant which processes natural gas for recovery of natural gas liquids and sometimes other substances such as sulfur.

Gas-Well Gas
The gas produced or separated at surface conditions from the full well stream produced from a gas reservoir.

Gas-Well Liquid
The liquid separated at surface conditions from the full well stream produced from a gas reservoir.

Gathering System
The network of pipelines which carry gas from the wells to the processing plant or other separation equipment.

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Heat Media (Heating Media)
A material, whether flowing or static, used to transport heat from a primary source such as combustion of fuel to another material. Heating oil, steam, and an eutectic salt mixture are examples of heat media.

Heating Value (Heat Of Combustion)
The amount of heat obtained by the complete combustion of a unit quantity of material. The gross, or higher, heating value is the amount of heat obtained when the water produced in the combustion is condensed. The net, or lower, heating value is the amount of heat obtained when the water produced in the combustion is not condensed.

Heavy End
The portion of a hydrocarbon mixture having the highest boiling point. Usually hexanes or heptanes and all heavier hydrocarbons are the heavy ends in a natural gas stream.

Hexanes Plus (Or Heptanes Plus)
The portion of a hydrocarbon fluid mixture or the last component of a hydrocarbon analysis which contains the hexanes (or heptanes) and all hydrocarbons heavier than the hexanes (or heptanes).

Hydrate
A solid material resulting from the combination of a hydrocarbon with water under pressure.

Immiscible
Liquids that will not mix nor blend to give homogeneity are said to be immiscible.

Inerts
Elements or compounds not acted upon chemically by the surrounding environment. Nitrogen and helium are examples of inert constituents of natural gases.

Isobutene
In commercial transactions, a product meeting the GPA specification for commercial putane and, in addition, containing a minimum of 95 liquid volume percent isobutane. Chemically, a hydrocarbon of the paraffin series with the formula C4HlO and having its carbon atoms branched.

Jacket Water
Water which fills, or is circulated through, a casing which partially or wholly surrounds a vessel or machine element in order to remove, add, or distribute heat in order to control the temperature within the vessel or element.

Joule-Thomson Effect
The change in gas temperature which occurs when the gas is expanded at constant enthalpy from a higher pressure to a lower pressure. The effect for most gases at normal pressure, except hydrogen and helium, is a cooling of the gas.

Lead Acetate Test
A method for detecting the presence of hydrogen sulfide by discoloration of paper which has been moistened with lead acetate solution. See ASTM D-2420.

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Lean Gas

(1) The residue gas remaining after recovery of natural gas liquids in a gas processing plant. (2) Unprocessed gas containing little or no recoverable natural gas liquids.

Lean Oil

Absorption oil as purchased or recovered by the plant, or oil from which the absorbed constituents have been removed.

Lift Gas

Gas used in a gas lift operation.

Light Ends

The low-boiling, easily evaporated components of a hydrocarbon liquid mixture.

Light Hydrocarbon

The low molecular weight hydrocarbons such as methane, ethane, propane and butanes.

LNG (liquefied natural gas)

The light hydrocarbon portion of natural gas, predominately methane, which has been liquefied.

Loading Rack

A structural and piping installation alongside a railroad track or roadway used for the purpose of filling railroad tank cars or transport trucks.

LPG (liquefied petroleum gas)

Refer to definition of "LP-gas".

LP-gas (Liquefied petroleum gas)

Predominately propane or butane, either separately or in mixtures, which is maintained in a liquid state under pressure within the confining vessel.

LRG (liquefied refinery gas)

Liquid propane or butane produced by a crude oil refinery. It may differ from LP-gas in that propylene and butylene may be present.

LTX (low temperature extraction unit)

A unit which uses the cooling of a constant enthalpy expansion to increase liquid recovery from streams produced from high pressure gas condensate reservoirs. Also called LTS (low temperature separation) unit.

Mercaptan,

Any of a homologous series of compounds of the general formula RSH. All mercaptans possess a foul odor.

Miscible Flood

A method of secondary recovery of fluids from a reservoir by injection of fluids that are miscible with the reservoir fluids.

Natural Gas
Gaseous form of petroleum. Consisting predominately of mixtures of hydrocarbon gases. The most common component is methane.

Natural Gasoline
A mixture of hydrocarbons, mostly pentanes and heavier, extracted from natural gas, which meets vapor pressure, end point, and other specifications for natural gasoline as adopted by the GPA. See GPA Standard 3132.

Natural Gas Processing Plant
Term used for gas processing plant, natural gasoline plant, gasoline plant, etc.

NGL (natural gas liquids)
Natural gas liquids are those hydrocarbons liquefied at the surface in field facilities or in gas processing plants. Natural gas liquids include ethane, propane, ,butanes, and natural gasoline.

Oil-Well Gas
Gas that is produced from an oil well

Odorant
An odoriferous compound added to natural or LP-gas to impart a distinctive odor for detection of fugitive vapors. Ethyl mercaptan is the most widely used odorant for LP-gas, while tertiary butyl mercaptan, usually mixed with small amounts of other compounds, is the predominant odorant for natural gas.

On-Stream Factor
The percentage of time a unit is on-stream.

Operating Factor
The percentage of time a unit is performing the function for which it was designed.

Outage
The vapor volume in a liquid vessel left for liquid expansion. Sometimes referred to as ullage.

Packaged Unit
A shop-assembled group of equipment and accessories which needs only foundations, inlet and outlet piping, and utility connections to make an operating unit.

Packed Column
A fractionation or absorption column filled with packing designed to give the required contact between the rising vapors and the descending liquid.

Peak Shaving
The use of non-conventional fuels to supplement the normal supply of pipeline gas during periods of extremely high demand.

Pentane-Plus
A hydrocarbon mixture consisting of isopentane (C_5H_{12}) and heavier components with higher boiling points.

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Pigging
A procedure for forcing a device through a pipeline for cleaning purposes, separating products, or inspecting the line.

Pipeline Gas
Gas which meets a transmission company's minimum specifications.

Propane
A normally gaseous paraffinic compound (C_3H_8). The term includes all products covered by GPA specifications for commercial and HD-5 propane. See GPA Standard 2140.

Commercial Propane,
A liquefied hydrocarbon product consisting predominately of propane and/or propylene and which conforms to the GPA specification for commercial propane as defined in GPASt andard 2140.

Propane HD-5
A special grade of propane consisting predominately of propane and which conforms to the GPA specification for HD-5 propane as defined in GPA Standard 2140.

Raw Gas
Unprocessed gas, or the inlet gas to a gas processing plant.

Raw Mix Liquid
A mixture of natural gas liquids prior to fractionation. Also called "raw make".

Recovery
That percent or fraction of a given component in the plant feed which is recovered as plant product.

Recycle
Return of part of a process stream to a point upstream from where it was removed to enhance recovery or control.

Reflux
In fractionation, the portion of condensed overhead returned to the column to enhance achievable purity of the overhead product.

Reflux Ratio
A way of giving a relative measurement to the volume of reflux. Usually referred either to the feed or overhead product.

Relative Density
The ratio of the mass of a given volume of a substance to that of another equal volume of another substance used as standard. Unless otherwise stated, air is used as the standard for gases and water for liquids, with the volumes measured at 15.56°C and atmospheric pressure (101.325 kPa).

Relief System
The system for safely relieving excess pressure to avoid exceeding equipment design pressure.

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Residue
The material which remains after a separation process. (1) Residue gas is that gas remaining after the recovery of liquid products. (2) Residue may also be the heaviest liquid or solid remaining after distillation or reclaiming process.

Retrograde Condensation (vaporization)
Condensation or vaporization that is the reverse of expected behavior. Condensation caused by a decrease in pressure or an increase in temperature. Vaporization caused by an increase in pressure or a decrease in temperature.

Rich Gas
Gas feed to a gas processing plant for liquid recovery.

Rich Oil
The oil leaving the bottom of an absorber. It is the lean oil plus the absorbed constituents.

RVP (Reid Vapor Pressure)
The vapor pressure of a material measured by the Reid Method and apparatus as detailed in ASTM Test Procedure D-323.

S & W (See bs&w)
Saturated compounds hydrocarbon compounds having no unsaturated carbon valence bonds. Natural gas and natural gas liquids are saturated compounds.

Saturated Liquid
Liquid which is at its boiling point or is in equilibrium with a vapor phase in its containing vessel.

Saturated Vapor
Vapor at its dew point.

Shrinkage
The reduction in volume of a gas stream by removal of some of its constituents such as for recovered products, fuel, or losses.

SNG (Synthetic or Substitute Natural Gas)
The gas product resulting from the gasification of coal and/or gas liquids or heavier hydrocarbons.

Solution Gas
Gas which originates from the liquid phase in an oil reservoir.

Sour
Liquids and gases are said to be "sour" if they contain hydrogen sulfide, carbon dioxide, and/or mercaptans above a specified level. It is also used to refer to the feed stream to a sweetening unit.

Sour Gas
Gas containing undesirable quantities of hydrogen sulfide, mercaptans, and/or carbon dioxide. It is also used to refer to the feed stream to a sweetening unit.

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Splitter
A name applied to fractionators, particularly those separating isomers (e.g., butane splitter refers to a tower producing most of the isobutane in the feed as overhead and most of the normal butane in the feed as bottoms).

Sponge Absorbent
An absorbent for recovering vapors of a lighter absorbent that is used in the main absorption process of a gas processing plant.

Stabilized Condensate
Condensate that has been stabilized to a definite vapor pressure in a fractionation system.

Stabilizer
A fractionation column designed to reduce the vapor pressure of a liquid stream.

Stage Separation System
A system of separators where the liquid portion of the well effluent is separated from formation gas and flash vapors

Stream Day
A continuous 24 hour period of plant operation.

Still
The column where the absorbed product is recovered from the lean absorption oil. In plants using a low molecular weight absorption oil, the still is designed as a fractionation column. In plants using a high molecular weight absorption oil, the still may use steam or other fluids as stripping medium. Also used to refer to regenerators in amine treating and glycol dehydration systems.

Strapping
A term applied to the process of calibrating liquid storage capacity of storage tanks in increments of depth.

Stripper
A column wherein absorbed constituents are stripped from the absorption oil. The term is applicable to columns using a stripping medium, such as steam or gas.

Stripping Factor
An expression used to describe the degree of stripping. Mathematically, it is KVfL, the reciprocal of the absorption factor.

Stripping Medium
As stated under "stripper", the medium may be steam, gas, or other material that will increase the driving force for stripping.

Sulfur Dioxide (SO_2)
A heavy, colorless, suffocating gas that is chemically an oxide of sulfur. Conversion of the gaseous sulfur oxides to sulfur is necessary for corrosion control, for health and safety reasons, and for complying with governmental standards.

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Sweet Gas
Gas which has no more than the maximum sulfur and/or CO2 content defined by (1) the specifications for the sales gas from a plant; (2) the definition by a legal body. Also, the treated gas leaving a sweetening unit.

Temperature Correction Factor
A factor for correcting volume at a given temperature to that at a specific reference temperature. Reference temperature most commonly used in the petroleum industry is 15.56°C.

Therm
A unit of gross heating value equivalent to (1.055) X 107 kJ.

Tonne
A unit of mass measurement, commonly used in international petroleum commerce; an expression for the metric ton, or 1000 kilograms.

Trayed Column
A vessel wherein gas and liquid, or two partially miscible liquids, are contacted, usually concurrently on trays. Also refer to packed column.

Turboexpander
Refer to definition of "expansion turbine."

Unsaturated Compounds
Hydrocarbon compounds having one or more unsaturated valence bonds, i.e., ethylene, propylene. These compounds are not found in natural gas streams or gas liquids because of their relatively high chemical reactivity. Unsaturates are produced by a thermal cracking or chemical reaction and can be found in synthetic gas (SNG) or light refinery gases (LRG).

Vapor Pressure (true vapor pressure)
The pressure exerted by the equilibrium vapor of a liquid when confined in a closed previously evacuated tank or test apparatus.

Vapor Pressure Gasoline
A descriptive phrase for natural gasoline meeting a specified vapor pressure.

Vapor Pressure, GPA
Vapor pressure as specified by GPA procedures.

Vapor Recovery
Equipment or process for the recovery of desired components from stock tank vapors or vapors from some other source.

Volatile Sulfur
An obsolete term referring to sulfur compounds that will vaporize readily (See sulfur).

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Weathering
The evaporation of liquid caused by exposing it to the conditions of atmospheric temperature and pressure. Partial evaporation of liquid by use of heat may also be called weathering.

Weathering Test
A GPA test for LP-gas for the determination of heavy components in a sample by evaporation under specified conditions.

Weight In Air
Weight compared to a standard with no correction for air buoyancy.

Wellhead
The assembly of fittings, valves, and controls located at the surface and connected to the flow lines, tubing, and casing of the well so as to control the flow from the reservoir.

Wet Gas
(1) A gas containing water, or a gas which has not been dehydrated. (2) A term synonymous with rich gas. Refer to definition of "rich gas".

Wobbe Number
A number proportional to the heat input to a burner at constant pressure. In British practice, it is the gross heating value of a gas divided by the square root of its gravity. Widely used in Europe, together with a measured or calculated flame speed, to determine interchangeability of fuel gases.

Property - any measurable characteristic of a substance, such as pressure, volume, or temperature, or a characteristic that can be calculated or deduced, such as internal energy.

State - when a system possesses a unique set of properties, such as temperature, pressure, density, and so on, at a given time. Thus the system is said to be in a particular state. A change in the state of a system results in a change -in at least one of its properties.

Equilibrium - a state in which there is no tendency toward change,

Phase - a completely homogeneous and uniform state of matter.

Ideal Gas - is an imaginary gas which obeys exactly certain simple laws such as the laws of Boyle, Charles, Dalton. No real gas obeys these laws exactly over all ranges of temperature, although "lighter" gases (hydrogen, oxygen, air, etc.) under ordinary circumstances obey the ideal gas laws with but negligible deviations.

Ideal Gas Law - from the work of Boyle and Charles, scientists developed the relationship now called the Ideal Gas Law. The equation used is $pV = n RT$. This equation can relate the volume, pressure, temperature, and the amount of a given gas.

Equations of State - relate the p- V - T properties of a pure substance (or mixture) by theoretical or empirical relations. The Ideal Gas Law is a simple example of an equation of state.

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Vapor - a gas below its critical point which can condense (i.e change its phase).

Gas - a substance which is above its critical point and is noncondensable.

Vapor Pressure - the pressure at which vaporization and condensation are at constant temperature and pressure under equilibrium conditions for a pure substance or mixture.

"Normal" Boiling Point - the temperature at which boiling will take place under a pressure of 1 atmosphere [101.3 kPa, 760 mm Hg].

Dew Point - the temperature at which a vapor starts to form a liquid during the process of condensation.

Bubble Point - the temperature at which a liquid starts to form vapor during the process of vaporization.

Saturated - when a vapor or liquid is just about to condense a drop of liquid or vaporize a 'puff of vapor respectively.

Superheated - when a substance is above its saturated vapor region. The degrees of superheat refer to the difference in temperature between the solution temperature and the actual temperature of a substance above the saturation region.

Subcooled - when a substance is below its saturated liquid region.

Triple Point - when a substance is at a set of conditions in which the solid, liquid, and vapor phases are all in equilibrium.

Multiphase Systems

Water can exist in many phases, solid, liquid and vapor. These states can change from one to another at the proper conditions with 'the addition or removal of the correct amount of energy. For instance:
liquid to solid : freezing
solid to liquid : melting
liquid to vapor : boiling
vapor to liquid : condensation
sublimation : solid to vapor

Pour Point

The pour point of petroleum oil is the lowest temperature, which the oil will flow or pour when it is chilled without disturbance under prescribed conditions.

Puking

A stabilizer or fractionator column is said to "puke" when the oil foams and rises in the column and through the vapour line.

Air

Air contains approximately by volume 78- 79% nitrogen; 20.95% oxygen; 0.94% argon; traces of carbon dioxide, helium,etc

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Ambient Air
The air surrounding equipment or in a certain area.

Anti-Foam Agent
A specific chemical agent used for combating and destroying a particular type of foam. Addition of anti-foam to soap suds will cause the soap bubbles to collapse.

Aqueous
Watery; of, pertaining to, or containing water

Atmosphere
Is the mixture of gases and water vapour surrounding the earth.

Atmospheric Pressure
The pressure of air at sea level exerted equally in all directions. The standard pressure is that under which the mercury barometer stands at 760 mm or 30 inches. It is equivalent to about 14.7 psia

Bleeding
Diverting from a line or vessel a small portion of the contained material usually accomplished by slightly "cracking" a valve on the line or vessel .

Bomb
A steel cylinder used as a testing device for conducting oil or gas tests under high pressure. Used for tests, such as sulphur content, and vapour pressure (Reid Vapour Pressure).

Breathing
The movement of gas (hydrocarbon vapours or air) in and out of the vent lines of storage tanks due to alternate heating and cooling.

Brine
Water, which is nearly saturated with, salts.

British Thermal Unit (Btu)
The heat required to raise the temperature of 1 lb of water through 10F.

Calibration
1. The graduation of a measuring instrument 2. The determination of error in a measuring instrument

Calorie
The amount of heat required to raise the temperature of 1 gram of water through1oC. The kilogram calorie (i.e. 1000 calories or 3.97 Btu) is also employed.

Calorific Value

The amount of heat obtained by the complete combustion of unit weight of fuel. It is normally expressed as calories per gram or Btu per pound. **The gross calorific value** represents the total amount of heat of combustion

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Capillarity
The rising or falling of the surface of a liquid in contact with a solid. The fluid actually rises above the normal level due to surface tension.

Combustion
Chemically, it is a process of rapid oxidation caused by the union of the oxygen of the air, the supporter of combustion with any material, which is capable of oxidation.

Decomposition
The breaking up of compounds into smaller chemical forms, through the application of heat, change in other physical conditions, or through the introduction of other chemical bodies.

Emulsion
A liquid mixture in which oil in minute globules is suspended in water or water in tiny droplets is suspended in oil.

Enthalpy
The heat content per unit mass expressed in Btu per lb.

Entrainment or Carryover
Relatively non-volatile contaminating material which is carried over by the "overhead" effluent from a separator, stabilizer column or an absorber. This may be as liquid droplets or finely divided solids suspended in a gas, a vapour or in a discrete liquid.

Explosive Limits
The limits of percentage composition of mixtures of gases and air within which an explosion takes place when the mixture is ignited. The lower limit of flammability corresponds to the minimum amount of combustible gas, which must be present to support combustion and the upper limit to the maximum amount of combustible gas, which can be present and still permit combustion of the mixture.

Flare Gas
Gas diverted to flare tips, stacks or pits to be burned.

Flue
A channel or passageway for smoke, waste gases, etc. As subsidiary tube or smoke duct in a chimney, or a tube carrying gases of combustion in a boiler or Firetube.

Gas Explosimeter
An Instrument for determining the explosibility of a gas-air mixture. it is used as a safety device in gas plant operations.

Heavy Ends
The highest boiling portion present. Also the hydrocarbons that have more carbon atoms than others.

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Initial Boiling Point

The temperature at which the first drop of distillate falls from the condenser during a laboratory distillation test.

Inspissation

Evaporation of the lighter components of petroleum which leaves behind the heavier residue.

Latent Heat of Vaporization

The amount of heat necessary to change unit mass of a liquid into vapour with no change in temperature.

Light Ends

The lower-boiling components of a mixture of hydrocarbons.

Lower Ends

The hydrocarbons that have a relatively lower boiling point; the opposite to heavier ends.

Moist Gas

Signifies a gas containing water droplets or moisture.

Specific Heat

The ratio of the quantity of heat required to raise the temperature of a body one degree to that required to raise an equal mass of water one degree.

Viscosity

That property of a fluid which determines its rate of flow. As the temperature of a fluid is increased its viscosity decreases and it therefore flows more readily.

Viscosity Index

An arbitrary number used to characterise the rate at which the viscosity of lubricating oil changes with changing temperature. Oils of high viscosity index exhibit relatively small change of viscosity with changing temperature and vice versa.

Volatility

The ease with which a product begins to vaporise. Volatile substances have relatively high vapour pressures and therefore relatively low boiling temperatures,

Chapter 8

Multiple choice questions

اختيار من متعدد

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1. **The fluid property, due to which, mercury does not wet the glass is**

A. surface tension C.cohesion

B.viscosity D.Adhesion

2. **Laminar flow of a Newtonion fluid ceases to exist, when the Reynolds number exceeds**

A.4000 **C.2100**

B.1500 D.3000

3. **The normal stress is the same in all directions at a point in a fluid, when the fluid is**

A.non-viscous. C.both (a) and (b).

B.incompressible. **D.having no motion of one fluid layer relative to the other.**

4. **Head developed by a centrifugal pump depends on its**

A.speed **C.both (a) and (b)**

B.impeller diameter D.neither (a) nor (b)

5. **In Centrifugal compressors, why does surge occurs?**

A. Surge occurs due to low pressure in the suction drum. C. Surge occurs due to high speed.

B. Surge occurs due to low flow at suction. D. None of the above (neither A, nor B, nor C)

6. **Loading/unloading ethylene requires:**

A. Loading arm overhaul **C. Loading arm cooling-down**

B. Loading arm dismantling D. None of the above (neither A, nor B, nor C)

7. **Why is pH measured in the boiler blowdown?**

A. To adjust the flow C. To inject detergent

B. To prevent corrosion D. To inject polyelectrolyte

8. **What is the physical meaning of saturated steam?**

A. It is a steam at low pressure. C. None of the above (neither A, nor B, nor C)

B. Steam at Dew point or at a point where all water transferred to vapor. D. It is a steam at high pressure.

9. **Sulphur dust is:**

A. Irritant & flammable C. Toxic

B. Irritant and toxic D. Corrosive only

10. **Which of the following statement is not correct?**

A. Traceability of the product is optional C. Quality policy determines organisational objectives

B. Processes transform inputs into outputs D. Efficiency is the relationship between result and resources

11. **In steam boilers, why is a continuous blowdown provided.**

A. To control level in steam boiler. C. To control the pressure.

B. To control the quality of steam. D. All the above (A + B + C).

12. **What is the purpose of the fast purging in a steam boiler?**

A. To remove the sludge from the boiler bottom C. To sample the water to check for composition

B. To replace part of the water with fresh make-up water D. To check the level inside the boiler drum

13. **Which of the following is not a quality principle?**

A. Customer focus C. Process approach

B. Continuous improvement **D. Maximum production on-specification**

14. **How many carbon moles are in 6.00 g of C?**

A. Two moles. **C. Half mole.** B. Three moles.

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15. On process plants why are process/utilities connections equipped with flexibles and specific fittings?

A. To make sure operator will recognize them   C. To facilitate the work of the operator

B. To prevent any mix of utilities

D. To prevent purging with the wrong utility and/or hydrocarbon contamination

16. In a distillation column, what is flooding?

A. It is the level increase in the column.   B. Pressure drop in the column.

C. It occurs when the liquid/vapour traffic is disturbed due to high velocity of the vapour and liquid is entrained upwards.

D. It occurs when the liquid/vapour traffic is disturbed due to low velocity of the vapour and liquid weeps through the plates.

17. In a distillation column, what is the sensitive tray?

A. It is the tray at which the feed to the column is placed in order to minimize temperature upsets.

B. It is the tray at which temperature in the stripping section is controlled.

C. It is the tray at which most of the light and heavy components are separated and fractionation occurs.

D.None of the above (neither A, nor B, nor C)

18. For centrifugal pumps, what is cavitation?

A. Cavitation occurs due to low level in suction drum.

B. Cavitation occurs when the NPSH available is less than the required NPSH.

C. It is the presence of vapour in the suction drum.

D. None of the above(neither A, nor B, nor C)

19. Why is saturated steam used in the different reboilers in the plant and not superheated steam?

A. To prevent corrosion   C. To limit thermal exchange

B. To reduce reboiler duty   **D. None of the above(neither A, nor B, nor C)**

20. For steam turbines, why is heating necessary before start up?

A. To get more power.   C. More speed.

B. More discharge pressure.   **D. To avoid thermal shock.**

21. What is Latent Heat?

A. It is the heat of a substance at ambient temperature.

B. Heat required to vaporise or to condense a gas.

C. Heat required to increase the temperature of 1 kg a substance by 1C.

D. Heat required to melt or to freeze a liquid.

22. What is Partial Pressure?

A. It is the pressure of a substance at ambient temperature.

B. Pressure required to vaporize or to condense a gas.

C. It is the pressure of individual component in a mixture of gas.

D. All the above (A + B + C).

23. What is Boiling Point?

A. It is the temperature required to vaporize the liquid.

B. Pressure and temperature drop in the column.

C. It is the temperature at which the vapour pressure of a liquid is equal to the atmospheric pressure.

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24. The net positive suction head (NPSH) of a centrifugal pump is defined as the sum of the velocity head and the pressure head at the

A.discharge. **C.suction minus vapor pressure of the liquid at suction temperature.**

B.suction. D.discharge minus vapor pressure of the liquid at the discharge temperature.

25. Pour point and freezing point is equal for

A.petrol **C.water**

B.diesel D.crude petroleum

26. In cracking furnaces or fired heaters, what is the advantage of using excess air in combustion?

A. Fuel consumption will be reduced.

B. Temperature will be better.

C. Complete combustion is ensured.

D. All the above (A + B + C).

27. Which of the following fractions of a crude oil will have the maximum gravity API (i.e. °API) ?

A.Diesel

B.Gasoline

C.Atmospheric gas oil

D.Vacuum gas oil

28. Short distance transportation of grain, gravel, sand, ash, asphalt etc. is done by using a ________ conveyor.

A.flight C.ribbon

B.slat or drag **D.screw**

29. Friction factor for fluid flow in pipe does not depend upon the

A.pipe length. C.fluid density & viscosity.

B.pipe roughness. D.mass flow rate of fluid.

30. Which one of the following is incombustible ?

A.H_2 **C. CCl_4**

B. C_2H_2 D. S

31. Fog is an example of colloidal system of

A.solid dispersed in gas. **C.liquid dispersed in gas.**

B.solid dispersed in liquid. D.gas dispersed in liquid.

32. In troposphere (the weather domain), the temperature 't' at height 'h' above the sea level in metres is given by (where, temperature at sea level is 15°C and t is in °C.)

A.$t = 15 - 0.0065 h$ C.$t = 0.0035 h - 15$

B.$t = 15 + 0.0065 h$ D.$t = 15 - 0.0035 h$

33. A high pressure boiler generates steam at a pressure greater than __________ kg/cm2 .

A.10 C.30

B. 50 **D. 80**

34. Which of the following is not categorised as a "mechanical operation" ?

A.Agitation C.Size enlargement

B.Filtration **D.Humidification**

35. To increase the reflux ratio what about the heat removed from the cooler

A- decrease **C- unaffected**

B- increase D- Equal

36. Characterization factor =12.5

A- **parrafine base** C- naphthenic

B- intermediate D- Non Of The above

37. True pressure is ………… reid vapor pressure

A- **higher (5-10%) than** C- Equal

B- lower (10-20%) than D- Lower(5-10%) than

38. Excess air in furnace in case of N.g is

A- 20 % C- 25 %

B- 15 % D- 12 %

39. Two substances with the same b.p :

A- difficult to separate by distillation

B- impossible to separate by distillation

40. catalytic reforming

A- endothermic reaction

B- exothermic reaction

41. fcc operates at

A- very low temp.

B- very high temp.

42. To increase the purity of the top product of distillation

A- increase reflux ratio

B- decrease reflux ratio

43. motor O.N and research O.N

A- M.O.N > R.O.N

B- M.O.N < R.O.N

C- M.O.N = R.O.N

44. kerosine fraction

A- 75 - 190°c

B- 190 - 250°c

45. deasphalting uses

A- propane

B- heavy oil

C- Light Oil

46. fuel oil choosing according to

A- API

B- sulfurcontent and viscosity

47. flash point of lube oil must be

A- low

B- high

48. The main constituents of LPG

A- propane and butane

B- methane and ethane

49. Rasching rings used for

A- packed tower

B- trays tower

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50. What are the best, conditions for hydrate formation?

A- High pressure, high temperature, and water saturated gas.

B- High pressure, low temperature, and water saturated gas.

C- Right combination of pressure & temperature, light ends hydrocarbon and free water.

D- Low pressure, high temperature, light ends hydrocarbon and free water.

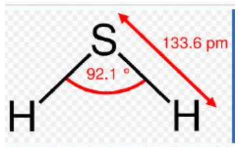
51. What is the molecular weight in pound mole of hydrogen sulfide (H_2S)?

A- 16 Pounds

B- 24 Pounds

C- 34 Pounds

D- 18 Pounds



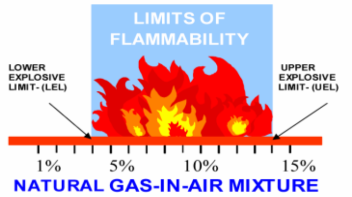
52. What is approximately the lower explosive limit of the natural gas?

A- 1 %

B- 10 %

C- 4 %

D- 15%



٥٣. In a throttling process, the pressure of an ideal gas reduces by 50 %. If Cp and Cv are the heat capacities at constant pressure and constant volume, respectively (Υ=Cp/Cv), the specific volume will change by a factor of

(A) 2

(B) 21/Υ

(C) 2(Υ-1)/Υ

(D) 0.5

54. If the temperature of saturated water is increased infinitesimally at constant entropy, the resulting state of water will be

(A) Liquid

(B) Liquid – vapor coexistence

(C) Saturated vapor

(D) Solid

55. For an exothermic reversible reaction, which one of the following correctly describes the dependence of the equilibrium constant (K) with temperature (T) and pressure (P) ?

(A) K is independent of T and P

(B) K increases with an increase in T and P

(C) K increases with T and decreases with P

(D) K decreases with an increase in T and is independent of P

56. Water is flowing under laminar conditions in a pipe of length L . If the diameter of the pipe is doubled, for a constant volumetric flow rate, the pressure drop across the pipe

(A) decreases 2 times

(B) decreases 16 times

(C) increases 2 times

(D) increases 16 times

57. The local velocity of a fluid along a streamline can be measured by

(A) Pitot tube

(B) Venturi meter

(C) Rotameter

(D) Orifice meter

58. For heat transfer across a solid-fluid interface, which one of the following statements is NOT true when the Biot number is very small compared to 1?
(A) Conduction resistance in the solid is very small compared to convection resistance in the fluid
(B) Temperature profile within the solid is nearly uniform
(C) Temperature drop in the fluid is significant
(D) Temperature drop in the solid is significant
59. In the McCabe-Thiele diagram, if the x -coordinate of the point of intersection of the q -line and the vapor-liquid equilibrium curve is greater than the x -coordinate of the feed point, then the quality of the feed is
(A) super-heated vapor (C) saturated vapor
(B) liquid below bubble point (D) saturated liquid
60. For which of the following combinations, does the absorption operation become gas-film controlled?
P. The solubility of gas in the liquid is very high
Q. The solubility of gas in the liquid is very low
R. The liquid-side mass transfer coefficient is much higher than the gas-side mass transfer coefficient
S. The liquid-side mass transfer coefficient is much lower than the gas-side mass transfer coefficient
(A) P & Q (C) P & S
(B) P & R (D) Q & R
61. The half-life of an nth order reaction in a batch reactor depends on
(A) only the rate constant
(B) only the rate constant and the order of the reaction
(C) only the rate constant and the initial reactant concentration
(D) the rate constant, initial reactant concentration, and the order of the reaction
62. In petroleum refining, catalytic reforming is used to convert
(A) Paraffins and naphthenes to aromatics (C) Gas oil to diesel and gasoline
(B) Paraffins to hydrogen and carbon monoxide (D) Light olefins to gasoline
63. The final boiling points of gasoline, diesel, atmosph gas oil (AGO) and lubricating oils vary as
(A) gasoline > diesel > AGO > lubricating oils (C) AGO > lubricating oils > diesel > gasoline
(B) lubricating oils > AGO > diesel > gasoline (D) lubricating oils > diesel > AGO > gasoline
64. The main unit processes used for the production of hydrogen from natural gas are steam reforming (SR), pressure swing adsorption (PSA), low temperature water gas shift reaction (LT WGS) and high temperature water gas shift reaction (HT WGS). The correct sequence of these in the plant is
(A) SR; LT WGS; HT WGS; PSA **(C) SR; HT WGS; LT WGS; PSA**
(B) PSA; SR; LT WGS; HT WGS (D) PSA; HT WGS; LT WGS; SR
65. A thermometer initially at 100°C is dipped at t = 0 into an oil bath, maintained at 150°C. If the recorded temperature is 130°C after 1 minute, then the time constant of thermometer (in min) is
(A) 1.98 (C) 1.26
(B) 1.35 **(D) 1.09**
65. The Bode stability criterion is applicable when
(A) Gain and phase curves decrease continuously with frequency
(B) Gain curve increases and phase curve decreases with frequency

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66. An equimolar mixture of A and B (A being more volatile) is flash distilled continuously at a feed rate of 100 kmol/h, such that the liquid product contains 40 mol % of A. If the relative volatility is 6, then the vapor product, in kmol/h, is

(A) 10 **(C) 25**
(B) 20 (D) 45

67. Maxwell's thermodynamic relations applies to the

A- chemical systems in equilibrium.
B- mechanical systems in equilibrium.
C- irreversible thermodynamic processes.
D- reversible thermodynamic processes.

68. Nusselt number is related to Grashoff number (Gr) in turbulent & laminar flow respectively, in respect of free convection over a vertical flat plate as

A. **$Gr^{0.25}$, Gr** C. Gr, $Gr^{0.25}$
B. Gr0.25, Gr0.33 D. Gr0.33, Gr0.25

69. If the demand for an item is trebled and the order cost is reduced to one third, then the economic order quantity

A. is trebled. C. decreases by a factor of 3.
B. **remains unchanged.** D. decreases by a factor of 1/3.

70. Transition from laminar to turbulent zone in free convection heat transfer is governed by the critical value of

A. Grashoff number. C. Reynolds number.
B. Grashoff number & Reynolds number. **D. Grashoff number & Prandtl number.**

71. Galvanic corrosion can not be prevented by

A. cathodic protection. **C.** usage of largest possible anodic area.
B. anodic protection. **D.** any one of these.

72. Fire in fuel gas pipelines is extinguished most effectively by

A. spraying water. **C.** fire fighting foam.
B. blanketting the area with nitrogen atmosphere. **D.** none of these

73. In a distillation column, what is flooding?

A. It is the level increase in the column.
B. Pressure drop in the column.
C. It occurs when the liquid/vapour traffic is disturbed due to high velocity of the vapour and liquid is entrained upwards.
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75. In cracking furnaces or fired heaters, what is the advantage of using excess air in combustion?

A. Fuel consumption will be reduced.
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C. More speed.

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82. Complete the following chemical reaction:

$2NaOH+CO_2$= …………

(A) Na_2CO_3+H2O (B) $NaCO_3+H_2O$ (C) $Na_2+H_2CO_3$

$2NaOH+H_2S$= …………

(A) $Na_2HS_3+H_2$ (B) $Na_2S+H_2S+H_2O$ **(C) Na_2S+2H_2O**

$CH4+O_2$= …………

(A) $CO_2H_3+H_2O$ **(B) CO_2+2H_2O** (C) CO_2+H_2O

$2C_2H_6+7O_2$= …………

(A) $CO_2H_3+4H_2O$ **(B) $4CO_2+6H_2O$** (C) $CO_2+H_2O+C_2H$

$S+O_2$= …………

(A) SO_2+H_2 **(B) SO_2** (C) SO_2+O_2

83. Which of the following is not a quality principle?

A. Customer focus
C. Process approach
B. Continuous improvement
D. Maximum production on-specification

84. Which of the following statement is not correct?

A. Traceability of the product is optional
C. Quality policy determines organisational objectives
B. Processes transform inputs into outputs
D. Efficiency is the relationship between result and resources

85. On process plants why are process/utilities connections equipped with flexibles and specific fittings?

A. To make sure operator will recognize them
B. To prevent any mix of utilities
C. To facilitate the work of the operator
D. To prevent purging with the wrong utility and/or hydrocarbon contamination

86. Which of the following is a correction?

A. Rework
C. Deviation
B. Concession
D. Scrap

87. In case of H_2S smell Outdoor operator must:

A. Try to detect the leak
C. Start water curtain
B. Take safety shower
D. Put escape mask and inform control room

88. Which of the following is correct?

A. Forklift operators hold a specific permit
B. Maintenance has a permanent traffic permit
C. Inspection is checking the forklift every day
D. Forklift speed limit is 40 Km/h

89. In the case you see a fire the first thing to do is:

A. To find foam extinguisher
C. To find a fire hose for watering
B. To inform control room
D. To find CO_2 extinguisher

90. Usage of scaffolding requires:

A. A special permit
C. A safety authorization
B. Maintenance authorisation
D. None of the above (neither A, nor B, nor C)

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91. Waste water specifications for release to the environment includes:

A. TAH B. NOx C. Viscosity **D. COD**

92. Which greenhouse gas is covered by the Kyoto Protocol?

A. Nitrogen B. Oxygen C. Hydrogen **D. CO2**

93. Which document provides HSE information on chemicals?

A. Delivery sheet C. Technical bulletin

B. Specification **D. MSDS**

94. What is the colour of mandatory signs?

A. Blue B. Red C. Yellow D. Black

95. Why are polymers liquid or solid at ambient condition?

A. Because they are thermoelastic

B. Because they have a very high molecular weight

C. Because polymers are extruded

D. None of the above (neither A, nor B, nor C)

96. Which of the following characterises a polyolefin polymerisation reaction an industrial processes

A. It generates heat C. All the monomer is consumed immediately

B. It generates cooling D. It is very slow

97. What is a runaway polymerisation reaction

A. A very dynamic plastic **C. An auto accelerating reaction beyond control**

B. A reaction starting too early D. None of the above (neither A, nor B, nor C)

98. How is the viscosity of a polymer measured

A. From its colour

C. From the amount of polymer flowing in a calibrated hole in a specific time

B. From the process parameters

D. None of above (neither A, nor B, nor C)

99. What is the difference between a volumetric pump and a centrifugal pump?

A. Centrifugal pumps are rotating and volumetric are not

B. Volumetric pumps are positive displacement pumps

C. Centrifugal pumps are positive displacement pumps

D. There is basically no difference between the two

100. How is the flow controlled in a centrifugal pump system

A. By throttling the suction valve

B. By throttling the discharge valve

C. By increasing the suction pressure

D. By slowing down the pump

101. Which one is not correct?

A. Reciprocating compressor flow can be adjusted through opening of the machine bypass

B. Reciprocating compressor flow can be adjusted through the suction pressure adjustment

C. Reciprocating compressor flow can be adjusted by throttling the discharge valve

D. Reciprocating compressor flow can be adjusted by cylinder dead volume adjustment

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102. Why is it required to increase the pH of Boiler Feed Water ?

A. Because boilers work better at high pH

B. Because boilers generate acid at high temperature

C. Because pure demineralised water can be very acidic and aggressive if polluted by traces of acid

103. Why is conductivity preferred to pH to follow Demineralised water quality?

A. because demi water pH is always 7

B. because demi water conductivity is easier to measure

C. because demi water is good electrical isolator

D. because demi water has very low ionic content concentration

104. Why may additives be used in polymer extrusion?

A. In order to improve the transformation characteristics in customers' machines

B. To protect the polymer in applications that are exposed to direct sunlight

C. To neutralise the residues in polymers where catalyst residues

D. All of the above (A + B + C)

105. What is observed in a centrifugal compressor if the suction temperature increases (suction and discharge pressure remain constant)?

A. Discharge temperature decreases

B. Power consumption decreases

C. Possible risk of condensing small droplets of liquid at the suction

106. What is observed in a turbine if the inlet temperature decreases (suction and discharge pressure remain constant)?

A. Discharge temperature decreases

B. Power delivered by the turbine decreases

C. Possible risk of condensing small droplets of liquid at the discharge

D. All of the above (A + B + C)

107. How can you detect a nitrogen leak?

A. By its distinctive colour

B. By its characteristic odour

C. By the fact that it spontaneously combusts in contact with air

D. None of the above (neither A, nor B, nor C)

108. What is a "double block and bleed"?

A. A chronic illness of which operators in the Petrochemical Industry suffer due to incorrect use of Personnel Protective Equipment.

B. A method of isolating process circuits prior to carrying out maintenance activities

C. A system used by maintenance to carry out lifting operations when a crane is not available

D. None of the above (neither A, nor B, nor C)

109. Nitrogen is often used to remove oxygen in process systems. If a vessel at atmospheric pressure containing 21% oxygen is pressured to 6 barg using nitrogen, what will be the oxygen concentration after this operation?

A. 3% C. 21%

B. 3.5% D. None of the above (neither A, nor B, nor C)

110. In solids handling, what is meant by dilute/lean phase conveying?

A. A system where the solids to gas ratio is low

B. A system which uses water to convey the solids

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111. In a refrigeration loop, what happens if the refrigeration compressor suction pressure is increased?

A. No impact on the process fluid being cooled
B. The temperature on the process fluid being cooled decreases
C. The temperature on the process fluid being cooled increases
D. None of the above (neither A, nor B, nor C)

112. In any polyolefin polymerisation process what will have an impact on the reaction?

A. Presence of oxygen
B. Presence of water
C. Presence of acetylene
D. All of the above (A + B + C)

113. Introduction of an olefin onto a freshly regenerated molecular sieve in a purification vessel without taking adequate precautions could lead to what effect taking place?

A. A rapid drop in temperature due to physical absorption of the olefin on the molecular sieve
B. A chemical reaction between the molecular sieve material and the olefin
C. An increase of temperature due to physical adsorption of the olefin on the molecular sieve
D. None of the above (neither A, nor B, nor C) since molecular sieves are totally inert materials

114. The sulfinol process is an example of:

(a) Physical
(b) Dry bed
(c) Chemical
(d) **Chemical/physical (hybrid)**

115. Some sweetening processes have a ‘‘dual function’’; they bring in gas Dehydration as well. Which of the following sweetening processes fall? into this category?

(a) MEA
(b) DGA
(c) DEA
(d) Sulfinol
(e) Molecular sieves

116. Most amine solvents are regenerated by:

(a) Lowering both T and P
(b) Increasing both T and P
(c) Lowering T and increasing P
(d) Lowering P and increasing T

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Chapter 9

Jobs Sites and Companies Emails

مواقع التوظيف و ايميلات الشركات

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Jobs Vacancies Sites　　أولا : أفضل مواقع التوظيف على الانترنت

- www.bayt.com/ar/egypt
- www.linkedin.com
- www.bezaat.com
- http://www.tankeeb.com
- http://www.im2work.com
- http://www.wzayef.com/ar
- http://www.jobs-eg.com
- http://jobs.egypt.com/ar
- http://www.jobsinegypt.com/Job/index.asp
- http://www.manpower.gov.eg/JobPublication.html
- http://www.egyptitjobs.com
- http://eg.3wjobs.com
- http://www.recruitegypt.net
- http://www.allcairojobs.com
- http://www.learn4good.com/jobs/langu.../country/egypt
- http://www.egyrec.com/
- http://www.masrawy.com/Classfied/
- http://www.jobsinegypt.com/Job/index.asp
- http://itjob-egypt.blogspot.com/
- http://www.shoghlanty.com/
- http://www.ewaseet.com/classifieds.p...country_id=ALL
- www.egypt.dubizzle.com/ar/jobs/search
- www.filbal.com
- www.jobs.gov.eg/jobs.aspx
- http://www.gulftalent.com/jobs/search

- Get a job ISA (Chemical Engineer)
- Operations Petrochemical , Oil and Gas
- وظائف مهندسين حديثى التخرج
- وظائف المصريين
- Jobs in Egypt
- Egypt Engineers
- وظائف
- وظائف البلد
- وظائف مصر
- وظائف خالية
- وظائف متاحة
- وظائف للجميع
- وظائفjobs
- وظائف لكل المصريين
- وظائف، منح، بعثات
- وظائف وأعلانات
- وظائف بالمملكة العربية السعودية
- وظائف سعودية
- وظائف وتدريب
- فرص وظائف المنظمات الغير حكومية
- وظائف دوت كوم
- ملتقى الساقية للتوظيف والتدريب
- جروب خاص بفرص العمل بالخارج
- عايز وظيفة؟ أشترك معانا
- فرص عمل بالخارج
- شغلانتى" *تابع لوقع شغلانتى لأعلانات وظائف الجرائد* "
- أعلانات الجرائد اليومية" *لا تدع اى أعلان بالجرائد تفوتك* "
- شغلنى شكرا
- الوظائف الشاغرة فى السعودية

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شركات القطاع العام

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21ش احمد عرابى – المهندسين – الجيزة تليفون3466377 : ، 3467922فاكس : ٣٠٣٥٤٣٤

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431طريق الجيش- لوران -الاسكندرية تليفون: ٠٣٥٨٢٤١٣٨- فاكس 03/5831279 :

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1شارع انور المفتى عمارات بنك الاسكان والتعمير – عباس العقاد – مدينة نصر ت. سويتش: ٢٦٠٣٣٦٤ فاكس 2603440 :

ناشيونال جاس
16شارع نهرو مصر الجديدة تليفون: ٤٥٠٨٠٤٦ فاكس 4508239 :

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الخاتمه

بسم الله الرحمن الرحيم

لاَ يُكَلِّفُ اللّهُ نَفْساً إِلاَّ وُسْعَهَا لَهَا مَا كَسَبَتْ وَعَلَيْهَا مَا اكْتَسَبَتْ رَبَّنَا لاَ تُؤَاخِذْنَا إِن نَّسِينَا أَوْ أَخْطَأْنَا رَبَّنَا وَلاَ تَحْمِلْ عَلَيْنَا إِصْراً كَمَا حَمَلْتَهُ عَلَى الَّذِينَ مِن قَبْلِنَا رَبَّنَا وَلاَ تُحَمِّلْنَا مَا لاَ طَاقَةَ لَ نَا بِهِ وَاعْفُ عَنَّا وَاغْفِرْ لَنَا وَارْحَمْنَا أَنتَ مَوْلاَنَا فَانصُرْنَا عَلَى الْقَوْمِ الْكَافِرِينَ (٢٨٦)

صدق الله العظيم

وهكذا لكل بداية نهاية ، وخير العمل ما حسن آخره وخير الكلام ما قل ودل وبعد هذا الجهد المتواضع أتمنى أن أكون موفقا في سردي للمواضيع السابقة سردًا لا ملل فيه ولا تقصير موضحًا أهميته للمهتمين بالعمل فى مجال الهندسة الكميائية و هندسةالغاز و البتروكيماويات. وفي النهاية لا أملك إلا أن أقول أنني قد عرضت رأيي وأدليت بفكرتي في هذا الموضوع لعلي أكون قد وفقت في كتابته والتعبير عنه وأخيراً ما أنا إلا بشر قد أخطئ وقد أصيب فإن كنت قد أخطأت فأرجو مسامحتي وإن ك نت فد أصبت فهذا كل ما أرجوه من الله عزوجل .

، وفقني الله وإياكم لما فيه صالحنا جميعا.

مهندس / مسعد مسعد داود

مهندس بترول بشركة بترول خليج السويس "جابكو"

محاضر فى هندسة الغاز و البتروكيماويات بنقابة المهندسين

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About The Author

Mosad Dawood Is A Process Engineer at Gulf Of Suez Petroleum Company (GUPCO/BP) as Well as an Instructor In Oil and Gas Processing Technology at Egyptian Engineers Syndicate. I work on Monitoring And Providing Plant operational Performance and Process Input for Plant Modification.

Misr Fertilizers Production Company (MOPCO) **January 2014**

Operation Engineer:

Responsible for following during normal operation start up , shut down and supervision for all activity during Ammonia Production .

Gulf Of Suez Petroleum Company (GUPCO/ BP) **July 2014 – Present**

Operation Engineer, (R/SH. Gas Plant):

Responsibilities and Duties

- Monitors operational reports (Daily, Weekly, Monthly, etc.) of operational facilities
- Prepare and Review all Work Permits, Job Procedures and Related Safety Documents
- Interacts with the HSE Advisor to coordinate the application of HSE standards in all procedures.
- Daily Contact With Towers , Vessels , Pipelines , Rotary and Static Equipment , Check and Monitor (P , T , L , Q) Which Keep All Processes In Safe Side and High Performance .
- Work on operational and maintenance troubleshooting assisting facilities as needed.

Process Engineer, (R/SH. Gas Plant):

Responsibilities and Duties

- Quality Control For Plant Products and Daily Calculating The Overall Recovery.
- Discover ways to increase plant efficiency or yield.
- Redesign processes that improve product quality, reduce operating costs, improve safety or protect the environment.
- Interfacing with working interest partners, service companies and regulatory agencies
- Studies and Suggest Plant Modifications and Provides Justifications To Enhance Plant Operations
- Monitors And Provides Plant operational Performance and Process Input for Plant Modification Using Aspen HYSY Simulation Software to Improve Hydrocarbon Recovery.

I am experienced as a class Trainer and on job Coach enjoying knowledge sharing with my Team where all courses presented in the following places: **Sept 2012 – Present**

- **Damietta Engineers syndicate " Training Center**
- **I learn Academy**

  - Instructor For Aspen HYSYS " All Versions "
  - Instructor For Natural Gas Processing Technology
  - Instructor For Plant Equipment " Process Point Of View "
  - Instructor For Natural Gas Applications LPG & LNG Technologies
  - Instructor For Chemical and Petrochemicals Engineering Diploma

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